

INFLUENCE OF PARENTS, PAST SCIENCE EXPERIENCES,
LOCUS OF CONTROL, SELF-ACTUALIZATION, AND GENDER
ON HIGH SCHOOL STUDENTS' ATTITUDE TOWARD SCIENCE,
SCIENCE ACHIEVEMENT, AND COMMITMENT TO COLLEGE
MAJORING IN SCIENCE AND NON-SCIENCE

BY

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I dedicate this dissertation to my wife, Roya Shahbazi Narchi, whose love and continuing emotional support helped me to complete this research.

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Abstract of Dissertation Presented to the Graduate School
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MAJORING IN SCIENCE AND NON-SCIENCE

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A causal model design was employed to investigate the influence of parental background, student's background, personality traits, and gender on high school science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science. Three hundred twenty-one eleventh and twelfth graders who were enrolled in three different levels of physics and chemistry courses (standard, honor, and advanced placement) were selected from three public high schools in Alachua County, Florida.

Four scales were used to measure variables of interest: Children's Nowicki-Strickland Locus of Control Scale (CNSIE), the Personal Orientation Inventory Scale (POI), and

the Test of Science-Related Attitudes Scale (TOSRA). A questionnaire to measure past science experience and demographic information was developed by the researcher. The Test of Science-Related Attitudes was used as a repeated measure at the beginning of semester term and at the end of the same semester.

The results indicated that students' past science experiences from elementary and middle school, number of science and mathematics courses taken in high school, and gender significantly impacted students' current attitude toward science and their commitment to the choice of science and non-science college majors. The findings revealed gender differences, in favor of male students, in variables of students' past science experiences, number of science and mathematics courses taken in high school, and attitude toward science. The female students demonstrated that they attained more self-actualizing traits than did males. In conclusion, students' past science experiences and attitude toward science play an important role in their commitment to the choice of science and non-science college majors.

CHAPTER 1 INTRODUCTION

The United States faces an alarming situation. The nation is increasingly dependent upon trained persons who can perform in industries specializing in science and technology. However, despite the well paid jobs waiting for graduates in these fields of study, youth in the nation's schools are not preparing for careers in these areas. Students in the United States have been characterized as lacking in the attributes necessary for scientific literacy (Welch, 1983). Furthermore, the performance of students in the United States who are bound for science, mathematics, and engineering programs is inferior to that of their counterparts in other countries, including Japan, Hong Kong, England, Sweden, and U.S.S.R. (IAEEA, 1986). In the United States, also, the numbers of students pursuing courses of studies in science and engineering are not high enough to meet the nation's needs. The proportion of the nation's cohort of 18 year olds who take college preparatory science courses is apparently smaller than the proportion in the other countries included in that study. Only 1% of United States senior high school students are reportedly enrolled in second year chemistry and physics classes. In contrast,

in Canada the numbers are 25 and 19% for chemistry and physics respectively, and in Japan, 16 and 11% respectively (OTA, 1989).

Nor is the situation improving. The numbers and percent of those entering as freshmen in the United States who express their intentions of majoring in the natural sciences or in engineering were fewer in 1986 than in 1978. In 1978, 27% of, or about 286,000 first-time, full-time freshmen entering the nation's four-year colleges and universities, planned to pursue majors in natural science or engineering. In 1986, 24% of, that is 246,000, freshmen expressed such intentions (OTA, 1987).

A further aspect of the problem of developing a larger pool of trained scientists and engineers is the fact that fewer females than males were intended undergraduate majors in science. In 1985, among males who were admitted to undergraduate programs in universities and colleges, 48% chose a science and engineering field for their major, whereas only 28% of the females were in those fields (NSF, 1988). Within the various areas of science and engineering, the differences by sex of those interested in pursuing careers were considerable. Of those interested in life and health sciences, about one-half were males and one-half were females. Fewer females as compared to males reported being interested in studies that required significant mathematical components, such as physics, chemistry, and engineering.

Women were reported to be substantially underrepresented in high school physics and calculus classes, college technical majors, and in careers in physical science and engineering (Jones & Wheatly, 1988).

The lack of interest of women in these careers is disturbing because females represent a large potential talent pool for the nation. The number of women choosing science has increased in recent years. Despite recent gains, their numbers have remained low in the engineering fields (Ware & Lee, 1988). Only 13% of the engineering degrees awarded in 1983 were awarded to women. In the same year, women received 28% of degrees in physical science (NSF, 1988).

The disinterest that many females demonstrated in regard to highly quantitative fields has been evidenced in high school. Somewhat more males than females enrolled in high school courses in these areas, and males tended to have a higher rate of achievement in these fields. The causes of this disparity between males and females in expressing interest, in taking courses, in achieving high test scores, and in aspiring to science careers have not been fully determined and remain subjects for further research (Lee, 1987).

In the education pipeline it is important for students to proceed towards their intended majors by taking prerequisite courses. When students enroll in more science

courses at high school, they will be better prepared for college level courses. High school is a critical period when students engage in their scientific plans. A study of high school students who are in advanced physics and chemistry courses and in advanced placement and honors courses in these areas might reveal information about factors that influence their attitudes toward science and their commitment to choice of a science major in college.

In a review of relevant literature on science education, a significant number of variables were identified that may contribute to high school students' science-related decisions and formation of science interests. Selected variables have been related to male and female participation in high school science and then to choice of science major in college. These variables will be examined in this study.

Variables Related to Science Participation
and Commitment to Choice of Science Major in College

Some of the variables that will be examined are related to high school students' backgrounds and have been identified as contributing to participation in science. These are parental education and occupation, past science experience, and precollege preparatory course work. These variables can be determined through checklists and questionnaires developed by the researcher and completed by the high school students.

The overall decline in number of students choosing science and the gender differences indicate that some students whose family and school experiences may have been positive influences toward their choosing science studies still do not choose science as a major in college. The literature suggests that there are personality constructs that may influence students' decisions to choose science and non-science majors. These constructs are self-actualization, attitude toward science, and locus of control.

Each of the variables used in this study is described next. The background variables are described first.

Parental Education and Occupation

Researchers have reported the strong influence of family background on adolescents' achievement in science. Kremer and Walberg (1981) examined 13 studies in which home environment variables were shown to have influenced student learning outcome. A high degree of parental involvement was related to positive science attitude and high degree of interest of adolescent students in science. Gasserly (1978) interviewed 125 girls from sophomore to senior years who were taking advanced placement (AP) courses. Students reported that a high proportion of their mothers had earned doctorate degrees (8.84%); a greater proportion of fathers (14.4%) had received doctorates; and all other parents had received master's or bachelor's degrees. This indicates

that higher parent education level may positively influence a female's interest in science. Kandel and Lesser (1969) found that parental influence is strongly related to students' overall educational goals and plans. Parents in science-related occupations are role models. It is reasonable to assume that parents who are knowledgeable about science will provide school books, educational science-related toys, and other science-related experiences for their children.

Past Science Experiences

Research in science education suggests that students who engage in science-related activities apparently develop their interests in science. When these activities have included positive experiences, students may be encouraged to pursue their interests in higher education in science. A number of researchers contend that females and males have equal interests in science and mathematics when they enter elementary school, but they have unequal science experiences (Kahle & Lakes, 1983; Kelly, 1985). By age 13, girls' interest in science-related activities decreases and the gap between male and female actual science-related experience widens. By age 17, differences in the number of science activities and in the quality of science backgrounds of males and females become even larger. This suggests a serious deficiency for females in science education (Kahle & Lakes, 1983). Those deficiencies may contribute to gender

differences in attitudes toward science and science achievement and in the choice of a science-related career (Kahle-Butler, Matyas-Lakes, & Hyung-Cho, 1985). Some researchers suggest that early participation in science hobbies and science-related extracurricular activities appears to be an excellent predictor of high school science interest (Wright & Hounshell, 1981).

Precollege Science, Course Work

Many curricular choices have been made and attitude toward science has been formed by the time students reach college (Deboer, 1985). The high school years, when students engage in life planning, are one important period for developing and maintaining student participation in science (Deboer, 1984). The National Science Foundation (1986) has compiled data on students' course work in mathematics and physical science during 1980. High school senior boys in this year in higher proportion than girls took courses in trigonometry (30 versus 22%), calculus (10 versus 6%), chemistry (39 versus 35%), and physics (26 versus 14%). Female students continued to account for a smaller fraction of those who took advanced placement tests in science and mathematics fields. However, females accounted for 50% of the advanced placement test takers in biology, but only 14% of those students who took tests in physics (The College Board, AP Yearbook, 1986).

It appears that the discrepancies between gender differences in science participation during high school years set the foundation for an imbalance in scientific careers between sexes as some researchers suggest. Female under-representation in scientific majors is partially due to females tending to complete fewer high school courses in mathematics and science than males (Baruch & Nagy, 1977; Berrman, 1983; Campbell & McCabe, 1982; Duntman, 1979; Thomas, 1984).

Gender

Steinkamp and Maehr (1983, 1984) studied gender differences in science achievement, aptitude, and motivation. Kahle (1982) reported a relationship of gender to cognitive and affective science outcome. In this study, gender differences with variables of interest will be examined.

External and Internal Locus of Control

Research related to locus of control and science education has increased educators' knowledge of the relation of individual differences to students' participation in science. Brooks and Hounshell (1975) studied groups of elementary science students who were in a nongraded school employing an open classroom philosophy and students in a graded school. The children's locus of control scale and the Stanford Achievement Test in science were administered. The authors found that significantly more students in the nongraded setting had an internal locus of control than

those in the graded school. The findings of this study led the authors to suggest that

the implication of locus of control research for science education appears to be significant in the fact that a student who has an internal locus of control has no less than a preconscious understanding that events in his immediate environment are not capricious happenings but consequences of actions over which he has influence. This personal belief in cause and effect relationships is prerequisite to comprehending the orderliness of natural phenomena and attaining scientific literacy. (Brooks & Hounshell, 1975, pp. 180-181)

Other researchers have reported significant findings with respect to locus of control and science achievement. Brody and Persson-Benbow (1986) found a significant relationship between achievement on mathematical reasoning and locus of control of adolescent gifted students, and Johnson and Butts (1983) reported a significant finding on college student achievement in biology and locus of control.

Reviewing the above studies provides evidence that adolescent students' participation in science and choice of a scientific major are influenced not only by intellectual capabilities but also by their personality characteristics.

Self-Actualization Traits

Abraham Maslow developed a theory that detailed the psychological traits of fully functioning individuals who were recognized as having actualized their potential. Maslow became interested in studying individuals who were accomplished. As a graduate student, he was fascinated by

two professors whom he admired. These two professors were Ruth Benedict and Max Wertheimer (Maslow, 1971b).

From studying Benedict, Wertheimer, and others, Maslow was able to postulate the psychological characteristics of individuals who appeared to be achieving their potential, who were psychologically fully functioning, and who were mentally healthy. Maslow, by observing and interviewing these accomplished people, was able to identify the common similar psychological characteristics possessed by all of them. He referred to these characteristics as self-actualizing characteristics and to individuals who possess them, as self-actualizing persons (Maslow, 1954). The list of characteristics of a self-actualizing person will be discussed in the literature review.

Although self-actualization theory was conceptualized on an adult population, Maslow (1968, 1971b) stated that all children have the potential to move forward and grow in the direction of self-actualizing. Thus, he implied that self-actualization is a process, not an end state (Daniels, 1982). Relating self-actualization characteristics to the study of late adolescent growth and academic ability "may shed light on the early manifestations of self-actualization, its dynamic effect upon achievement" (Wollam, 1986, p. 15).

Self-actualization relates indirectly to education. Research indicates that the self-actualizing students are

better suited to succeed academically (Farmer, 1984). When it comes to science and self-actualization, Maslow believed that

science can be a path to the greatest fulfillment and self-actualization of men. It can test his highest powers, bring him to his greatest heights, and bring out everything most admirable in him. The true scientist can be a model of the fullest human development, and the life of science can be a path to the greatest joys and satisfaction. (Maslow, 1971a, p. 94)

Research in science education and the construct of self-actualization has been carried out by some researchers. Heintschel (1978) analyzed the relationship between science teachers' self-actualization and science students' attitude and achievement. Bjorkquist (1982) studied a group of college students in a preparatory course for teaching elementary physical science. The details of these research studies will be described in the literature review.

Maslow's theoretical concept of self-actualization will help to identify students who have interests and abilities in science and who are able to make a commitment to a science major. Such students may have positive attitudes toward science.

Attitude Toward Science and Science Achievement Among Adolescents

Students' attitude toward science has been linked to a perception of self and the ability to learn (Haladyna, Oslen, & Shaughnessy, 1982). Some researchers have reported

that in comparison to females, male students tend to have more positive attitudes toward science and are more motivated to achieve in science (Baker, 1983; Fish, 1979; Handley & Morse, 1983; Peterson, Kauchak, & Yaakobi, 1980; Ward, 1979).

A number of researchers who have investigated adolescent students' science achievement have suggested there was a significant gender difference in adolescents science performance (Erickson & Erickson, 1984; Walberg, 1967; Zerega, Haertel, Shiow-Ling, & Walberg, 1986).

A number of factors have been identified as influencing students' science achievements, attitude toward science, and commitment to choice of science and non-science majors. The current study is to examine background and personality factors that seem to predict these variables indicated by students' self-report.

Statement of the Problem

There is a need to encourage students to take more physical science and mathematics classes in high school and to further encourage them to pursue scientific and engineering careers. In order for the United States to maintain its competitive edge in the marketplace, more students need to be recruited into physical science and engineering fields (Smith & Gessler, 1989).

Evidence suggests that many students in high school make life plans, taking courses to prepare for their intended college major (Lee, 1987). A crucial time for encouraging students to pursue science careers is in high school.

An investigation of the background and personality trait variables of those students enrolled in high school physical science (e.g., physical science, physics, and chemistry) courses will help to identify some factor, or factors related to students choosing science courses, and the influence of these factors on commitment to intended college majors. High school educators could then utilize this information to identify and assist other students who do not choose science courses. In addition, this information would be helpful in the encouragement of students who have displayed abilities but who lack commitment to a major in science and engineering fields.

Purpose of Study

This study was an investigation of the influence of parental background, student's background, personality traits, and gender on high school students' science achievement, attitude toward science, and their commitment to science and non-science careers. The hypothesized relationships among these variables are discussed in Chapter 3.

This study was carried out by investigating three groups of eleventh and twelfth graders who were currently taking physical science (e.g., physical science, standard, honors, and advanced placement physics, chemistry) courses. The first step determined the impact of predictor variables on each group's attitude toward science and science achievement. The second step of the investigation determined the impact of all predictor variables on student commitment to choice of science and non-science majors.

Research Questions

The following questions have been developed to determine the impact of predictor variables on response variables of science achievement, attitude toward science, and commitment to choice of majoring in science and non-science.

1. Is there a significant impact of past science experiences of eleventh and twelfth graders on science achievement, attitude toward science, and commitment to the choice of majoring in science or non-science?
2. Is there a significant impact of parental background of eleventh and twelfth graders on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?

3. Is there a significant impact of number of science and mathematics courses taken in high school on eleventh and twelfth grade students science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?
4. Is there a significant impact of self-actualization traits, and locus of control construct of eleventh and twelfth grade students on their science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?
5. Is there a significant impact of gender on eleventh and twelfth grade students on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?
6. Is there a significant impact of science achievement, and attitude toward science of eleventh and twelfth grade students on their commitment to the choice of majoring in science and non-science?
7. Is there a significant difference between scores of pretest and posttest of eleventh and twelfth grade students attitude toward science, as

measured by the Test of Science-Related Attitudes (TOSRA)?

Significance of the Study

The study may contribute to educators' understanding of male and female high school students having a number of personality traits and past science experiences associated with their achievement in science and choosing a scientific major. Knowledge of this nature can be readily used to identify some internal barriers that may be related to participation of students in science and subsequent commitment to science education, particularly in physical science and engineering fields.

The research of this study can provide information to secondary teachers and counselors that could be used in designing interventions to encourage students to enroll in more physical science courses during their high school years. Encouragement and an active interest on the part of teacher and counselor in students' science interest may lead students to enroll in college preparatory courses and so continue their science education after high school (Ware and Lee, 1988).

Definition of Terms

Standard Physics I and Chemistry I

These two semester courses are offered in high school for eleventh and twelfth graders. Students are required to have Algebra I or approval of the instructor as part of the prerequisites for each. These courses provide students with introductory concepts in physics and chemistry.

Honors Physics I and Honors Chemistry I

These courses are offered in high school for eleventh and twelfth graders. Students are required to have Biology I honors, Algebra II honors, and recommendation of previous science instructors as part of the prerequisites for these courses. These courses provide students with a rigorous study of the concepts in physics and chemistry on course materials more advanced than those used in standard Physics I and Chemistry I.

Advanced Placement Physics and Chemistry

These courses provide college level content in chemistry and physics and prepare students seeking credit and/or appropriate placement in college chemistry and physics courses. Students who perform successfully on the advanced placement examination may receive college credit from participating colleges.

Summary

It is important to encourage more high school students to become interested in majoring in physical science and engineering fields. There are a number of background and psychological variables identified as possibly contributing to students' participation in these science areas. These variables and their relationship to student choice of science major in college need to be identified. Having knowledge of these variables will help educators and counselors who are assisting high school students to plan to major in science.

CHAPTER 2 REVIEW OF RELATED LITERATURE

In this study the impact of background and personality variables on eleventh and twelfth grade students' science achievement, attitude toward science, and commitment to choice of majoring in science and non-science were examined. This chapter provides a review of the literature pertinent to this investigation. Included are studies dealing with the two sets of variables, background and personality variables, that are related to science participation and commitment to choice of science major in college. Background variables consist of family, past science experience, precollege course work, and gender difference. Psychological variables are self-actualization traits, characteristics of the self-actualizing person, locus of control, and attitude toward science. The last variable in the review is science achievement.

Variables Related to Science Participation and Commitment to Choice of Science Major in College

In the literature relevant to this study, a number of variables have been identified as related to high school students' participation in science and their choice of

science and non-science major in college. Among the variables cited, family is a strong influence on students' participation in science and choice of major in scientific area.

Family Background

Parents can highly influence their children's initial interest in science by providing relevant books and materials, being involved with their children's homework, and encouraging science activities outside school (Simpson and Troast, 1982). Parents who themselves have had higher educational background have the knowledge to assist and to influence their children.

In data from 1985, seniors who intended to go to college indicated the median number of years of education completed by fathers and mothers was about 14.0 years and 13.5 years, respectively. A high number of both fathers and mothers were employed in positions that required bachelor or advanced degrees (NSF, 1988).

Simpson and Troast (1982) suggested that parents influence the child's initial interest and continuing interest in science. Parental influences were perceived as being relevant to the child's choice of career and social goals. In their predictive study on careers in science, Neujahr and Hansen (1970) found, from data on high school students who majored in science in college, that these

students tended to come from homes where fathers were employed in science-related occupations. They also reported that these students' parents were frequently involved in their children's science-related activities.

Data obtained from a 1985 survey on the winners of the Westinghouse Science Talent Search (WESTS) are a good example of the influence of parents on students' science careers and aspirations in science. The WESTS is one of the United States' oldest high school competition in the science area. Data indicated that a number of students involved in the study became scientists, and some have gone on to earn Nobel Prizes. The science winners claimed that a parent, close relative, or teacher played a critical role in their decision to become scientists. Frequently, male family members had played an important role in influencing the winners' plans to study science (Survey of Westinghouse Science Talent Search Winners, November 1985).

The survey also reported that 35% of the science winners' fathers were scientific or engineering professionals. Interestingly, the science winners reported that they decided to pursue science careers when they were in high school.

Families may also influence students negatively in regard to science. Graham (1978) and Kelly (1981) reported that lack of parental expectation and encouragement affected

girls who did not do well in science. Findings from these studies suggest that families play an important role in shaping students' attitude toward science and students' plans for science careers. One significant way families influence children is by providing science experiences.

Past Science Experiences

Research has shown that students' past science experiences had an impact on their goals and science plans. These experiences might have influenced boys and girls differently; however, some researchers suggested that past science experiences begin in early childhood. The different toys given to boys and girls to play with and the games they play contribute in providing boys with different cognitive experiences (Erickson & Erickson, 1984). The toys commonly given to boys require more exploration and assembling than those given to girls. This suggests that from early childhood boys are expected to be more independent and manipulative (Jones & Wheatly, 1988).

Kahle and Lakes (1983) analyzed data from the 1978 National Assessment of Education Progress Survey on three age groups, 9, 13, and 17 years old. They found that in all three age groups, females reported fewer "hands on" activities with magnets, electricity, heat, solar energy, and erosion. Instead, females had more experiences than males with three material experiences: living plants, sound, and human behavior.

A significant difference was also found between 13 and 17 year old males and females in all extracurricular science activities assessed. Females participated less often than males in activities such as watching TV science shows, reading books, magazines, and newspaper articles on science, and working with science projects or hobbies. In field trip experience, many more males than females reported that they had visited factories, weather stations, electric plants, and radio/television stations (Kahle & Lakes, 1983). Other studies have also reported a lack of female involvement in extracurricular science activities (Kahle-Butler, Matyas-Lakes, & Cho-Hyung, 1985; Steinkamp & Maehr, 1983).

Among past science experiences, teacher interaction with students in science class was cited in a number of studies as having an important role in shaping students' attitudes toward science and their science plans. Sadker and Sadker (1985) observed teachers' interactions with fourth, sixth and eighth graders in language art and mathematics classes. They found that regardless of subjects, the male students received more teacher attention than females. Girls were expected to sit quietly and raise their hands any time they wanted to answer a question, while males called out the answers. Males were allowed to be aggressive, but girls were told that being aggressive was inappropriate. The authors suggested that this pattern

between teacher and student may amplify the problem of sex differences in interaction.

At the high school level, Becker (1982) studied high school geometry classes. She found that teachers paid more attention to male students by approaching them to check their work and providing help, while female students often asked for help. Females tended to be quieter in the classroom. Becker believed that males in the study received 70% of all positive contact and encouragement from the teachers that would help students in their academic studies.

Bank, Biddle, and Good (1980) suggested that teachers may favor students of their own sex. Because there is a lack of female teachers in science and engineering fields, there may be a correlation between the sex of teacher and interaction affecting the achievement of females negatively. It is important that males and females are equally encouraged to engage in science activities and to be involved in extracurricular activities related to science.

Precollege Course Work, Gender Differences

College bound seniors represent the largest potential pool of future scientists and engineers. The evidence suggests that precollege course work is the foundation for potential scientists. Data indicated that, in comparison to male mainstream students, females and some minority groups at precollege level take fewer years of mathematics and science courses, and they also were less inclined to take

advanced courses in these fields. Specifically, in precollege level courses, male high school seniors had often enrolled in the physical science (e.g., earth science, chemistry, and physics) courses at the basic and advanced levels; however, females were more likely to have taken either biology or advanced biology (NSF, 1988).

In 1985, the average number of years of physical science courses completed by males was 2.08 compared to 1.74 by females. In the biological sciences, the average for females was slightly higher than that for males: 1.44 versus 1.40 years.

The 1986 Scholastic Aptitude Test (SAT) data show that males continued to score substantially higher than females on the mathematics portion of the SAT. Although there has been some change on the scores of males and females on the verbal section, scores for the mathematics section have remained constant since 1976 (Admissions Testing Program of the College Board, College Bound Senior, 1975-1986).

The evidence suggests that females do not represent an equal number of science majors in physical science and engineering compared to males. A number of researchers have reported that females' mathematical achievement in high school was a strong predictor of their choosing a science major (Campbell & McCabe, 1982; Ware & Dill, 1986; Ware, Steckler, & Leserman, 1985).

Campbell (1986) suggested that the differences between the precollege science preparatory courses taken by males and females were primarily caused by the different treatment that boys and girls received from parents, teachers, and counselors. Males were encouraged to be interested in mathematics and science, and females were discouraged. As time passed, females felt less confident than males about mathematics. They appeared to believe that they did not have ability in mathematics and studied less for the course. Eventually, this resulted in females having lower achievement scores.

Other researchers have reported that personality factors contributed more to sex differences. In choice of precollege science course taking, Kelly (1981) claimed that attitudinal factors are major influences contributing to the under-representation of women in science courses and careers. Koballa (1988) conducted a study with female junior high school students to determine their intention to enroll in at least one elective physical science course (e.g., physical science, chemistry, physics) in high school. Fishbein and Ajzen's theory of reasoned action was used to test the hypotheses. According to this model, "the intention to perform a certain behavior is a function of the weighted attitude toward performing the behavior and the weighted subjective norm" (Koballa, 1988, p. 479). The effects of external variables (e.g., science grades,

academic ability) on females' intentions to enroll in one physical science course in high school were mediated by the theoretical constructs.

The findings supported some hypotheses: females' intentions to enroll in one elective physical science course in high school were found to be unrelated to academic ability, science grade, and attitude toward science, while their intentions were strongly related to the attitude toward the behavior and subjective norm. However, from these findings, it was concluded that the "absence of a significant relationship between intention and attitude toward science has definite implication for those exploring and testing means to encourage females to enroll in elective science and pursue science career. . . . Furthermore, the belief that taking physical science, physics or chemistry in high school will help in preparing for a future career should be emphasized" (Koballa, 1988, p. 489).

Self-Actualization Traits

The term self-actualization was first used in 1939 by Kurt Goldstein (Bonney, 1969; Gibb, 1968; Ewen, 1980; Pervin, 1980). Self-actualization was considered to be the focal motive of all the characteristics of human behavior and functioning (Goldstein, 1939).

The development of the concept of self-actualization has received the attention of Rogers (1951, 1959) and other theorists, but the foremost psychologist involved in

expanding upon this concept was Abraham Maslow (Daniels, 1982; Rogers, 1962). Maslow (1937) published his first research on the study of human "dominance feeling," later called "self-esteem." Five years later, he published his popular book Theory of Human Motivation. He continued writing on a variety of topics in psychology until his death in 1970 (Hoffman, 1988).

Maslow (1943) broadly based his theory of motivation on a set of needs or goals necessary for an individual's psychological growth. This set of needs was called the "hierarchy of needs" that begins with physiological needs or "primary needs." Physiological needs are related to the body and what it requires to maintain good health. Needs at this level include oxygen, food, water, sleep, sex, and warmth. Maslow (1970) stated that "undoubtedly these physiological needs are the most prepotent of all" (p. 36). After an individual has gratified these needs, the next higher needs on the hierarchy become the primary motivator of an individual's growth.

The level above physiological needs is that of the needs for safety. Safety needs are concerned with how safe and secure individuals feel in their environment, how protected from outside threats. Maslow (1970) believed that "the healthy and fortunate adult in our culture is largely satisfied in his safety needs" (p. 41). They are economically secured and psychologically healthy--having a

peaceful, smooth running, stable, and well-protected life against any possible real threats.

Once the safety needs have been satisfied, the needs of love and belonging will emerge. In this level of needs is a person's desire to have an affectionate relationship with people in general. This need can be satisfied in a process of giving and receiving when a person is loved either by his family or a member of a social group. Satisfying the need for love and belonging will allow the next level of need to emerge. This is the level of self-esteem. The needs in this state are related to a desire for self-esteem, self-respect, self-confidence, and the esteem of other people. Maslow (1970) stated that "satisfaction of the self-esteem need leads to feelings of self-confidence, worth, strength, capability, and adequacy . . . but thwarting of these needs produces feelings of inferiority, of weakness, and helplessness" (p. 45).

Self-actualization is the last need in Maslow's hierarchy of needs to be gratified for an individual's growth. The term self-actualization, as Maslow (1943) used and developed it, refers to an area of psychological growth in which the person is fully using his talents, capacities, and his potentials (Knapp, 1965; Maslow, 1954).

Although self-actualization is the final level of the hierarchy of needs, Maslow failed to clearly specify whether he viewed it as a state of ultimate satisfaction of needs

for individual growth or considered it a continuous process of growth (Daniels, 1982). Nevertheless, it was emphasized that an individual will not reach a higher level of need if lower ones have not been gratified. Maslow's conceptualization of the hierarchy never clarifies what conditions are essential in meeting the lower level needs or how one can attain the highest level, that of self-actualization (Seipp, 1983). While Maslow did not provide an explicit explanation of the process, he did observe and gather data from people whom he considered to be ideal individuals, data that constituted the certain characteristics of those he called self-actualized individuals.

Characteristics of Self-Actualized Individuals, Self-Actualization Scales

Maslow's description of the characteristics of self-actualized individuals (1950, 1970) was based on data gathered by observing his friends and acquaintances. Nevertheless, he (1950) was convinced that all of the characteristics he found among his friends were common to all other self-actualized people. These characteristics are as follow.

Perception of reality. Self-actualized people see the world and accept it as it really is, not as they wish it to be. They tend to be objective about their observations of things known to them. They seem not to feel threatened and

frightened by the unknown. The unknown is accepted, and they are comfortable with it. At the same time, they see themselves free of superstitions. As Maslow (1970) expressed it, "they do not have to spend any time laying the ghost, whistling past the cemetery, or otherwise protecting themselves against imagined dangers" (p. 155).

Acceptance (self, other, nature). Self-actualized people tend to accept their own human nature despite its discrepancies and weaknesses. As this is closely related to self-acceptance and to the acceptance of others, they do not play games or try to impress others in order to gain self-acceptance. On the contrary, they try to establish a genuine relationship with other people regardless of their differences. When it comes to the nature of human growth, self-actualized people look at and accept the process of human growth, sex, pregnancy, menstruation, and growing old, as normal changes in the human body rather than feeling guilt, shame, or anxiety about these processes.

Spontaneity. Self-actualized people are deeply spontaneous by nature and non-conforming. They seem to be relatively spontaneous in their behaviors and far more spontaneous in their inner life, thoughts, and impulses. This allows them to be conventional if an occasion requires it, whereas an ordinary person is automatically conventional. This outward conformity to convention hides their deeply essential spontaneous nature.

Creativity. Creativity is considered to be a universal characteristic of self-actualized people. Maslow believed that the creativity of self-actualized people extended beyond conventionally recognized form, such as art, music, and writing, to other areas that are not as readily apparent. They seem to be creative in all types of situations; being creative is not as much something they do as something they are (Lowry, 1973).

Autonomy, independence of culture and environment. Self-actualized people tend to be more independent and growth-motivated. They do not depend on the real world for their personal growth and needs satisfaction; rather they depend on themselves. They look within to develop and find their potentials.

Philosophical, unhostile sense of humor. A sense of humor is a very common characteristic of self-actualized people. They possess a different kind of humor. Their sense of humor is not directed at someone; rather, it is more closely allied to a form of philosophy than to anything else. Their humor is thoughtful and does not have a hostile intention.

The democratic character structure. Self-actualized people have a special kind of humility. They tend to be friendly individuals and have an ability to relate to other people regardless of their class, political belief, education, or their race. It often seems as if self-

actualized people are not even aware of these differences in other people. They appear to be open to other people's ideas and knowledge, and this makes them more tolerant of others.

Means and ends. Self-actualized people do not consider themselves to be either religious people, in an orthodox sense, or atheists. They tend to be spiritual individuals with meaningful individualized beliefs. They also do not see themselves being bound to dichotomies of the moral/ethical or right/wrong conventional and religious principles. On the contrary, they tend to analyze moral and ethical issues on the basis of universal principles.

Continued freshness of appreciation. In general, self-actualized people have a positive outlook on life and a great appreciation for what is happening around them. In their daily life, the moment-to-moment of living can be a thrilling, exciting, and ecstatic experience.

Maslow's vision and his work on self-actualization theory are considered to be unique. They have inspired many people to produce significant numbers of empirical studies throughout the social sciences (Hoffman, 1988). The literature review indicates that several inventories have been developed since 1960 that attempt to measure self-actualization. These inventories appear to include Maslow's concept of self-actualization in their scales, and they

claim that each inventory measures self-actualization. These inventories are described below.

The Northridge Developmental Scale (NDS), developed by Gowan (1974), consists of 90 items. From these 90 items, 81 represent the major part of the self-actualization scale. Each item has four unrelated statements about personal attitudes, values, experiences, or beliefs. For each item the subjects are asked to select the statement that is most true for him, or if none of the responses are representative, subjects are to choose the fifth response, "none of above." The NDS has three subscales: authoritarianism, depression, and neuroticism. These subscales are supposed to determine three types of psychopathology.

The Bonjean-Vance Self-Actualization Scale (BJSA) (Bonjean and Vance, 1968) was developed from Argyris's interviewing technique which was based on Maslow's hierarchy of needs. Argyris's interview was designed to be used in investigations of industrial/organizational patterns of employees.

Jones (1975) developed the Jones Self-Actualization Scale (JSAS) based on self-actualization characteristics as defined by Maslow. The JSAS is composed of 40 items. The items are alternately keyed, one positively and one negatively, to have less transparency. The positive items

represent the 19 characteristics of Maslow's self-actualization.

Shostrom (1964) developed the Personal Orientation Inventory (POI) to measure self-actualization. The POI consists of 150 two-choice behavioral judgment items. Each item reflects a degree of self-actualization as theorized by Maslow (1954; 1971b), both positively and negatively expressed. A respondent is asked to choose between a positively and negatively worded response that best describes him/her (Shostrom, 1966). Knapp and Shostrom (1976) explained that the reason for developing the POI was to "provide a standardized instrument for the measurement of values and behaviors hypothesized to be important in the development of the self-actualizing person" (p. 3).

The Self-Actualizing Value Scale (SAV) is one of ten subscales of the POI. The SAV has 25 forced-choice value statements that reflect the characteristics of Maslow's self-actualizing people. According to R.R. Knapp (1976), individuals who score high on the SAV appear to hold the values of self-actualizing people. Of all inventories reviewed, the POI appears to be the instrument most widely used in studies measuring self-actualization.

Self-Actualization and Academic Achievement

This review of the literature indicates that self-actualization researchers in the last 30 years with the

student population in college and high school levels dealt more with students' personal experience than with their academic achievement. Self-actualization studies that show college student achievement are reviewed. Second, the studies with high school students are reported.

Reporting on college students, Leib and Snyder (1967) investigated the effect of group discussion on under-achievement and level of self-actualization by utilizing the POI. Twenty-eight underachieving students taking psychology classes were selected. Students participated either in a discussion or lecture group. They were matched in two groups according to their score on the inner support scale of the POI. No significance was found between the discussion and the lecture groups in their level of self-actualization.

In a later study Leib and Snyder (1968) investigated the relationship between students' achievement and positive mental health as measured by the POI. A direct relationship was not found between achievement and positive mental health.

Unlike Leib and Snyder, Johnson (1967) reported significant findings on relationship between self-actualization and academic performance. Two groups of successful and unsuccessful college freshmen in education were compared. Success was defined as an end of semester grade of C or better. The two groups were compared according to age and levels of aptitude (SAT 1,000 or above,

900-999, below 900). The results suggested that the academically successful female with SAT scores of 1,000 or above had a significantly higher score on the self-actualization (SAV) scale on the POI. Johnson (1967) concluded from the result that "it may be assumed that the academically successful female student tended to hold values more similar to those of self-actualized people than did the unsuccessful female student" (p. 64).

In supporting Johnson's study, Wills (1974) reported that females he tested scored higher on the self-actualization construct than did males. The POI was administered to 242 males and 238 females enrolled in either composition or psychology courses at Oregon State University. Wills chose the lowest 59, the middle 56, and the highest 56 scores for each sex on the POI Inner-Directed Scale. It was found that each female group showed a higher level of self-actualization than did each of the male counterpart groups. Wills (1974) reported that females, in general, demonstrated a higher level of self-actualization than did males. He concluded that "this matter has important implications for those involved in research . . . needs to be more fully researched and incorporated into self-actualization theory" (Wills, 1974, p. 226).

In a multiple regression study, Smith (1973) included the POI scores with high school rank and SAT verbal and math scores to improve the prediction of the cumulative (GPA) of

467 freshmen at the University of Maryland. The addition of the 12 scales of the POI to HSR and SAT scores improved the predictability of males' GPA. Among the 12 scales of the POI, time competency/incompetence, and outer/inner-directed ratio scores significantly contributed to predicting the females' GPA.

In another multiple regression study of the self-actualization construct, McKissick (1976) studied 106 senior females at William Wood College to predict students' academic achievement. Students were placed in either liberal arts or career major groups. The self-actualization factors were used as predictors of academic achievement as measured by GPA. The inner-directed scale of the POI contributed significantly to the prediction of career majors' achievement. Among all of the POI subscales, existentiality contributed to predicting career major achievement, while the subscale of spontaneity contributed to the liberal art students' achievement.

In reporting studies on the relationship between self-actualization and high school students' achievement, Wollam (1986) conducted a study with 88 high school gifted students in their junior year to determine if self-actualization traits and scholastic aptitude test score (PSAT), in a regression design, were significant predictors of students' academic achievement. The result indicated that the gifted high school students, as a whole, had significantly higher

scores on the 10 of the 12 POI scales compared to the scores of the heterogeneous high school sample. However, the self-actualization measure was not a statistically significant predictor of gifted high school students' grade point average. But, the PSAT was a statistically significant predictor of gifted students' GPA.

In addition, the findings have shown that the gifted females in the study scored higher in the POI scales. This suggested that they were more self-actualized than their male gifted counterparts. Specifically, female students gained higher scores on scales of spontaneity, self-regard, and the ability to deal with opposites in life than did male students.

Wollam (1986) concluded that the POI in the study may not be an effective predictor of academic achievement because of the methodological constraints. The study dealt with a homogeneous population. It was proved that correlation coefficients are affected by the range of individual differences within a group, so "the more homogeneous the ability of the students, the lower the possible regression" (p. 80). Furthermore, the author also recognized that the small sample size of 88 particularly affected the reliability of the regression equation in the study.

In another study with high school students, but with a heterogenous group, Patterson (1988) examined the effect of

175 students' participation in community services on their process of self-actualization. There were two groups of students--those required to participate in a program of community service (RPS) and those not required (NRP) as a part of high school graduation requirements. The POI was used as the repeated measure at the start of the study, again after approximately 20 hours of community service work, and finally after 40 hours of service work.

No significant differences were found in the scores of the POI of students who participated from 0 to 20 hours in a program requiring community service work. Significant differences in the POI score participants were reported when students completed community service work beyond the 20 hours. In addition, results of the study indicated that there appears to be a significant interrelationship of the level of participation and gender, with self-actualization, as measured by the other-directedness scale of the POI. Males' scores remained the same across all the trials. All female groups' scores dropped in the first and second trials, but females' scores were slightly higher on the feeling reactivity (Fr) scale.

Patterson (1988) suggested that other extracurricular activities that students are involved in, both school and community related, may provide adequate opportunities for growth in self-actualization. The author recommended that "the inner-directedness and time competence scales of the

POI are among those potentially most useful to the researcher regarding adolescence" (p. 99).

Other researchers have also reported a significant relationship between self-actualization construct and high school students' performance. Elliot (1970) found that self-actualizing high school students were better at learning to listen and trusting themselves compared to non-self-actualizing students. A positive relationship was found between high school students' level of self-actualization and measures of student intelligence (Damm, 1970). In a multivariate analysis of variance, pretest and posttest designed study with gifted and nongifted high school students, Wooddell, Fletcher, and Dixon (1982) assessed differences between groups on the five future related variables from the POI and the Rotter's (1966) internal control. The POI and Rotter scores showed a definite trend toward higher self-actualization and internal control for the experimental groups. In addition, significance was found in inner-directedness between groups from pretest to posttest (Wooddell et al., 1982).

Studies reviewed on the relationship of self-actualization construct to high school students' performance reported a number of significant findings. This suggests that the self-actualization construct appears to be a useful variable for identifying the nonintellectual factors that

may contribute to high school students' performance in various subject matters.

Science Education and Self-Actualization

Self-actualization was the central idea underlying Maslow's educational studies. The goal of education, according to Maslow, "is ultimately the self-actualization of a person, the becoming fully human, the development of the fullest height the human species can stand up to or that particular individual can come to" (Maslow, 1971a, pp. 168-169).

The question researchers have addressed is how can this educational goal be achieved. Ivie (1982) suggested that schools must be staffed with the type of teachers who are self-actualized so that they can help to further this goal by providing an appropriate educational environment in which students move toward the road of becoming self-actualizing individuals.

The self-actualization construct has been related to the education process. This concept was related by Maslow to science and science education. Maslow (1971a) believed that science can be the path to the greatest fulfillment and self-actualization of individuals. Science can test the individual's highest power, bring the individual to the greatest heights, and bring out everything most admirable in the individual. Maslow believed that "the scientist who

combines them all in his own person, and who knows when to use which, we may call the self-actualizing scientist" (Maslow, 1971a, p. 99).

The relationship between science education and self-actualization has been studied by some investigators. Heintschel (1978) investigated the relationship between the level of self-actualization of secondary school science teachers (biology and chemistry) and students' achievement and attitude toward science. It reported that teachers' level of self-actualization, as measured by the POI, had a significantly positive impact on students' science achievements.

The impact of the teacher's level of self-actualization on student attitude toward science was different within each subject area. For biology, there was no significance found between the level of teacher's self-actualization and student attitude toward science. But, a significance relationship was found between the teacher's level of self-actualizing and student attitude toward science in chemistry. This means the higher level of teacher self-actualizing contributed to the positive attitude of students toward science. However, Heintschel (1978) concluded that the significant relationship found between teacher's level of self-actualizing and the student's attitude toward science appeared to be conditioned by the subject area taught.

Bjorkquist (1982) conducted a study with 36 female and 20 male students majoring in elementary education. Students were divided equally into the two types of methods courses in physics and chemistry defined as "traditional and humanistic." The traditional course emphasized the basic competencies in teaching science, whereas the humanistic course was aimed at developing self-actualization. Two instruments were designed--one to determine an individual's self-estimated proficiency in science (SEPS) and another to measure absolute and relative levels of anxiety specific to the teaching of science (ASTS, RATS). These instruments were administered to both groups. It was hypothesized that the traditional course would be best suited for students with the low SEPS and the humanistic course would be better for those with high SEPS. Findings indicated that neither of the method courses, based on scores found in the ASTS and RATS, was superior.

Bjorkquist (1982) suggested that the lack of significant findings in the study may be related to the similarity in some features of the courses. The courses also were given on the same school premises. Many materials were commonly used, although they were used differently according to the techniques employed with the different groups.

In the review of science education research, this investigator found a few studies that dealt with the

self-actualization construct. However, research in this area with high school students is lacking.

Locus of Control and Science Education

Locus of control refers to a person's expectation that success or failure is due to internal or external factors. Internal locus of control is defined as an individual's general belief that events are a consequence of one's own action and thereby under personal control, while external locus of control refers to the perception of these events as being unrelated to one's own behavior. Events happened due to chance, luck, or fate (Rotter, 1966).

Bar-Tal and Bar-Zohar (1977) reviewed a number of studies in locus of control. They found that 36 studies reported a positive correlation between students' academic performance and locus of control. Many other researchers have found a positive relation between an internal locus of control and school achievement (Gardner & Beatty, 1980; Lee & Lieh-Mak, 1984; Morgan & Culver, 1978; Nowicki & Roundtree, 1971).

There are two scales commonly used for student achievement to measure locus of control. The Rotter Internal-External Scale (RIE) and the Children's Nowicki-Strickland Locus of Control (CNSIE). Rotter (1966) developed the Rotter Internal-External Scale (RIE) that is composed of 29 pairs of statements (including six filler

pairs). These statements are arranged in a forced choice format. One statement in each pair is thought to represent an external orientation and the other an internal orientation. Rotter (1966) believed that the I-E locus of control is a stable trait in adults. The Children's Nowicki-Strickland Locus of Control, developed by Nowicki and Strickland (1973), is a paper and pencil instrument of 40 questions requiring a yes and no response. The items describe reinforcement situations across interpersonal and motivational areas such as affiliation, achievement, and dependency.

A number of researchers in science education used the locus of control construct to determine students' and teachers' performances. Brody and Persson-Benbow (1986) investigated a group of adolescents who scored higher on a verbal or mathematics test, compared with a group of students who were less talented to determine the perception of self-esteem, locus of control, popularity, and depression. They reported that the verbally and mathematically talented students showed a greater internal locus of control and less popularity than the comparison students. Brody and Persson-Benbow suggested that students of high ability feel they have more control over their lives.

Medin (1985) conducted a study to determine the relationship between text anxiety, locus of control, and

mathematics achievement placement with seventh and eighth grade students. The Nowicki-Strickland locus of control and the Sarason Test Anxiety Scale for children were used. Two hundred six students (95 girls and 111 boys) of the seventh and eighth graders were enrolled in a below-average, on-grade, or accelerated mathematics classes in the Montgomery County (Maryland) school system. Significant findings were reported: the seventh and eighth grade students in the below-average mathematics class experienced more anxiety and were more external in the locus of control orientation (they felt less in control of their success and failures) than students in either the on-grade or accelerated mathematics classes. The interaction of locus of control and mathematics achievement placement level also was found to be significant at the $p < .05$. Medin (1985) suggested that these findings can provide some information for an experimental program to be established for better teaching techniques and modified curricula. Such programs may provide more effective ways to teach below-average mathematics achievers.

In a study of the relationship between science achievement and locus of control with college students, Johnson and Butts (1983) investigated the relationship between science achievement, attitude toward science, and locus of control with junior college students. The students were observed in their time engaged in classroom, as

measured by student's attendance and interaction with the teacher during the eleven class time lectures. No evidence was found to support a relationship between students' locus of control and attitude toward science with their engaged time in the classroom.

Schafer (1981) conducted a study to assess the effect of college student's individualized goal setting in audio-tutorial (A-T) biology classes on locus of control. He also examined the effect of locus of control pretesting on end of course measurement of posttesting of locus of control. The Rotter locus of control scale was administered to 60 students in an introductory, A-T, college zoology course. Students were randomly assigned to treatment and control groups. The control group completed the course in the usual manner, while the treatment group, in addition to the usual material, also used a different format, which was developed for an optional mini-course. The optional mastery provides students with greater control over means and ends of course.

The results indicated that there was no significant effect found for either of two audio-tutorial techniques on locus of control for the treatment and control groups. In addition, the pretesting of locus of control did not have significant impact on the posttested locus of control. The small sample size was reported to be a factor contributing to the researchers not finding statistical significance in the study (Schafer, 1981).

In contrast to Schafer's report, Haury (1989) reported a significant finding in a science locus of control study. The science locus of control (SciLoc) orientation, developed by Haury (1984), was used as a predictor of attitude toward science teaching with 104 students who enrolled in a science methods course for preservice elementary teachers. The researcher employed a path analysis design. The results suggested that the SciLoc orientation was a major contributor to attitudes expressed toward science teaching among students in a science methods course. The author contended that the subjects' self-perception and control orientation influenced their attitudes toward teaching science to a greater extent than did general academic performance (Haury, 1989).

Science Related Attitude Among Adolescents

Simpson and Oliver (1985) investigated adolescents' attitude toward science and achievement motivation with approximately 4,000 science students who were randomly selected from sixth through twelfth grades. The scores of students on attitude and motivation achievement for each grade were analyzed using an analysis of variance. Main effect for attitude toward science, time, grade, gender, race, and class were included. A summary of this analysis was reported as follows.

1. Attitude toward science of adolescent students steadily declined from sixth to eighth grades. The sharpest decline was shown from seventh to eighth grades.
2. Males exhibited considerably more positive attitudes toward science than females. This discrepancy was true for each grade level except the ninth grade.
3. The attitude toward science for all students declined sharply from the beginning to the middle of the year within each grade, and then there was a slow decline from the middle of the year to the end of the year.
4. The achievement motivation score of adolescent students declined consistently from the sixth grade through tenth grade.
5. Female students at each grade level appeared to be highly motivated to achieve compared to their male counterparts.
6. Black and white students have shown a consistent decrease in attitude toward science from time 1 to time 2 of testing.

Simpson and Oliver (1985) concluded that the results of the study supported Hurd's (1978) report that impact of science courses commonly taught to adolescent students in most schools do not produce a positive attitude toward science

and adolescents' eagerness to continue taking science courses in high school and college.

In a longitudinal study, Oliver and Simpson (1988) reported significant findings relating to high school students' attitude toward science and science achievement. With a multiple regression analysis design, the attitude toward science measure was used to predict the tenth, eleventh, and twelfth grade students' achievement in science.

The analysis demonstrated that attitude toward science was not only a significant predictor of students' science achievement, but it also accounted for a significant part of variance in achievement. Specifically, it was reported that attitude toward science was a good predictor of the twelfth grade students' achievement in chemistry. Based on the results from the study, the authors contended that there is a change in the attitude of students toward science over time. Encouragement resulted in improved science achievement of students.

The relationship of adolescent with his/her family and peer group to his attitude toward science has often been assessed. Talton and Simpson (1985) reported that peers influenced the adolescents' attitude toward science. The relationship between two variables with students from sixth through tenth grades was assessed. As the school year proceeded, the students did more class work together and

developed a sense of friendship, as they referred to each other as my science partner. This relationship increased significantly over grades six, seven, and eight, and peaked in the ninth grade.

Findings from this study support the notion that the relationship of peer influence with science attitude among adolescents appears to be significant; as "peer attitude toward science increases, so does individual student attitude toward science" (p. 21). However, the research design and statistical procedure employed for the study did not allow a claim to be made that there is a causality between peer attitude toward science and individual attitude toward science (Talton & Simpson, 1985).

Talton and Simpson (1986) extended the longitudinal study to determine the influence of other variables on adolescents' attitude toward science. In a linear regression analysis, the measure of attitude of adolescents toward science, developed by Simpson and Troast (1982), was used. The three subscales of the instrument--family, self, and classroom environment--were selected to predict the sixth through tenth grades attitude toward science.

The three categories of variables--self, family, and classroom environment--contributed significantly to prediction of adolescent students' attitude toward science as follows: self variance explained 38-55% of the variance, family variance predicted 13-39% of the variance, and classroom environment accounted for 46-73% of the variance.

The finding suggests that the family, self, and classroom environment play a significant role in a student's attitude toward science. These results led the authors to conclude that

it is important for educators to realize that while a teacher may have an influence in developing positive student attitude within the classroom, other factors also need to be considered. If we are to truly develop a positive attitude toward science, the home environment needs to play an important role as well. (Talton and Simpson, 1986, p. 373)

In supporting Talton and Simpson's findings, Schibeci and Riley (1986) reported the influence of home environment and background variables on students' perceptions on science attitude. The data used to investigate the influence of student background on attitude toward science were drawn from two random samples comprised of 350 and 323 17-year-old students from the 1976-1977 National Assessment of Educational Progress (NAEP) Survey.

The study followed a causal model analysis by using the LISREL IV Statistical Program (Joreskog and Sorbom, 1978). It reported that home environment, homework, and parental education background substantially influenced students' science attitude (Schibeci and Riley, 1986).

Gender differences between adolescent students' attitude toward science and science career have been reported by several researchers. Handley and Morse (1983) conducted a study with 155 adolescent students, at two year

intervals, to determine the relationship between the students' self-concept and gender role perception to science achievement and for attitude toward science. The Science Opinionnaire (SO), developed by Fisher (1973), was administered to all the students.

The findings revealed that more changes were observed between attitude toward science and gender role variables over the two year period. The males' stereotyped attitude, that is, the male adolescents' belief that they have more leadership and the ability to succeed in science, was positively correlated with attitude toward science. In addition, the stereotyped attitude of males' dominance in science and the female groups' acceptance of this stereotyping were also correlated with attitude toward science on three factors of the science participation scale.

The girls in the study accepted the view of higher expectation for males and the idea that males tended to be more interested in science. However, the findings indicated that gender role perception was more associated with attitude toward science for both sex groups, and little difference was observed for both groups in achievement at both grade levels (Handley & Morse, 1983).

It was suggested that females' lack of confidence in female ability and their underrepresentation in scientific careers is due to females' view that science is a male domain (Fox, 1981; Hoyenga & Hoyenga, 1979; Kahle & Lakes,

1983). Particularly, females tended to avoid a career in physical science (Vockell & Lobonc, 1981). Male dominance of physical science occupations is an important factor in developing a "fear of success" among women (Janda, O'Grady, & Capps, 1978). Male dominance of the physical science classroom also could have a similar effect. Females considered physical science to be masculine, an attitude found also among teenage gifted students. In general, boys preferred careers in physical science, as the girls preferred humanities although many of the same girls were interested in math. Girls' occupational goals in science were distinctly different from those of the boys (Kerr, 1985).

Research indicated that mathematically gifted females, a group that could be expected to choose mathematical or scientific careers, do not always do so. Their choice of a career depended upon their role-specific self-concept as being competent in mathematics (Hollinger, 1983). The role-specific self-concept is an internal attitudinal barrier where females come to believe they cannot or should not engage in male dominated occupations (Barnett, 1974).

There are two common inventories used to measure adolescent students' attitude toward science, the Scientific Attitude Inventory (SAI) and the Attitude Toward the Subject Science Scale (ATSSS).

The Scientific Attitude Inventory (SAI), developed by Moore and Sutman (1970), has a 60-item likert-type instrument with a 4-point response scale and was designed for high school students. Construct validity was established by field testing the inventory with three groups of low ability tenth grade biology students. A test-retest reliability was reported of 0.934.

An inconsistency reliability of the SAI has been reported in a number of studies. Campbell and Martinez-Perez (1976) reported that the SAI scores did not predict performance in a science method course. Novick and Duvdvani (1976) surveyed 684 tenth grade students; no significant differences were found on attitude for type of school and type of curriculum. Munby (1983) identified 30 studies in which the SAI had been used. The conclusion was that researchers were not certain about what is measured by the SAI, and that allows for the claim that the SAI is conceptually doubtful. Therefore, it needs rewording before it can be used with confidence.

The Attitude Toward the Subject Science Scale (ATSSS), developed by Nyberg and Clarke (1982), is the instrument based on the Ajzen and Fishbein (1980) attitude theory. This theory, "theory of reasoned action," was developed to understand and predict an individual's behavior. A pool of 21 items was formed by using the format of Ajzen and Fishbein's theory. Items concerned with students'

performing various behaviors were related to learning of tenth grade science, and to assess student attitude toward various school subjects. The ATSSS reliability over four weeks after initial data collection was 0.82.

Krynowsky (1988) identified two major concerns with attitude measures used in science education, including the ATSSS scale. They are the lack of conceptual clarity in defining attitude toward science and some psychometric problems in the instruments. Munby (1980) found most attitude toward science assessments focused on individual's feelings and beliefs, and less on the concept of scientific attitude toward science.

In this study the test of science-related attitude (TOSRA), an Australian instrument to measure science-related attitude, was chosen. The TOSRA was developed by Barry Fraser (1981). The TOSRA was conceptualized on the aims of science education as proposed by Klopfer (1976).

Sex Difference in Science Achievement Among Adolescents

A considerable number of researchers in science education have concentrated on gender differences of students' science achievement. A few studies have focused exclusively on adolescent students' sex differences and achievement (Zerega et al., 1986).

Adolescents' sex differences in science achievement were assessed in 3,049 17-year-old students from the 1976

National Science Assessment of Education Progress (NAED). The sample was composed of an almost equal number of girls and boys in the eleventh grade. A three way analysis of variance model was employed to determine the relationship among the variables of SES, race, and sex.

Analysis of the data revealed a significance in the late adolescents science achievement. Males scored higher than females in achievement. Interestingly, there were no significant gender differences found when the data on 13-year-olds were compared at the early adolescence period girls and boys did equally well in science achievement. But, four years later, the male adolescents' achievement level was higher than their female counterparts (Zerega et al., 1986).

The analysis of the 1981-1982 data from the National Science Assessment revealed that 13 and 17-year-old boys achieved at a higher level than girls on concepts such as experimental design model, hypotheses, and error measurement. In 1985 NAEP data also showed that 17-year-old boys' scores on math and science were significantly higher than the girls' scores (Welch, 1985).

The adolescents' gender differences in science achievement are more pronounced in physical science. Two decades ago, Walberg (1967) administered the Reed Science Activity Inventory to a national sample of physics students, 725 boys and 322 girls, who were in the eleventh and twelfth

grades. Five dimensions of science activities in the inventory were analyzed. The girls were reported to be involved more in three dimensions--academic, nature, and applied life--than boys, while boys were reported to be concentrated on the tinkering and cosmology related activities.

The findings led Walberg to a number of conclusions. Girls are inclined more to the animated aspect of science, such as natural study and applied life, and boys tend to favor the inanimate aspect of science such as tinkering and cosmology. In addition, Walberg suggested that boys tend to be interested in activities involving physical manipulation, while girls are more interested on discussion of science application (Walberg, 1967).

Erickson and Erickson (1984) found significant gender differences in science achievement among a large group of fourth, eighth, and twelfth grade students in schools in British Columbia, Canada. Erickson and Erickson reported males in the study out-performed females in physics, chemistry, and earth/space science at all three grade levels. Moreover, the data indicated that the differences between males' and females' performances in biology at grade twelve was minimal compared to the differences in physics score. The males far out-scored the females.

Erickson and Erickson (1984) believed that the sex differences in eleventh and twelfth grade level students

physical science achievement are in all probability, unrelated to ability due to gender. Sex differences may be related to the fact that a large proportion of female students tended to enroll in biology courses and had avoided physical science, especially physics. The larger proportion of the females were enrolled more in biology courses and were enrolled lesser in physical science courses than was reported by other researchers (Keeves & Read, 1974; Kelly, 1981).

Other investigators have provided an explanation for why gender differences exist in adolescents' science achievement. Males tended to rate the moral and social environment of science classes more positively than females (Zerega et al., 1986). Males, feeling good about science classes, tended to be high achievers. This supports evidence from a number of countries. Researchers reported that class climate predicts cognitive and achievement gains (Walberg, 1983).

Erickson and Erickson (1984) suggested that social-cultural factors are working to give males an early advantage in exposure to scientific experiences, but biological factors contribute to a lesser degree. However, other studies suggest that sex-related differences in achievement due to spatial abilities are apparent (McGee, 1979; Sherman, 1978)

Summary

In this literature review, the variables employed in this study have been found to be related to students' commitment to a science career. However, no study was found in which all these psychological and background variables were considered together. Causal modeling was used as the methodology in this study to track the following variables: parental background, past science experiences, precollege course work, gender, locus of control, self-actualization, attitude toward science, and science achievement in adolescent students.

CHAPTER 3 METHODOLOGY

In this study the influence of parental background, past science experience, self-actualization traits, locus of control, and gender of high school students on science achievement, attitude toward science, and then the impact of these variables on students' commitment to a science major were investigated. In this chapter the research design with independent (predictor) and dependent (response) variables, population characteristics, procedures, hypotheses, and data analysis are presented.

Research Design

The research approach used in this study was pre- post-experimental, regression in design. Specifically, the research design employed the One Way Path Causal Modeling technique (Asher, 1976). The study consists of six predictor variables and three response variables. The six predictor variables are (a) parental background, (b) student past science experiences, (c) number of science and mathematics courses taken in high school, (d) gender, (e) self-actualization traits, and (f) locus of control (internal/external). The response variables are (a) science

achievement, (b) attitude, and (d) commitment to majoring in science and non-science at the college level. The design is shown in Figure 1.

All predictor variables, as shown in Figure 1, on two response variables, science achievement and attitude toward science, were assessed. Next, the impact of these two response variables, on commitment to choice of majoring in science and non-science was determined. Last, the impact of all variables on commitment to choice of majoring in science and non-science was assessed.

Population Characteristics

The population for this study was composed of male and female eleventh and twelfth grade students of mixed racial backgrounds who live in urban and rural communities in Alachua County, Florida. The Alachua County Public School System served 1,560 eleventh and 1,400 twelfth grade students during the 1989-1990 school year at six high schools, according to school records (School Board of Alachua County, 1989). Buchholz, Eastside, and Gainesville High Schools are located in urban areas of Gainesville. There are three high schools, Hawthorne, Newberry, and Santa Fe, located in rural areas. Two high schools in the urban area and one in the rural area were selected for this study based on their large enrollment. The two high schools in the urban area are Gainesville High School with a total of

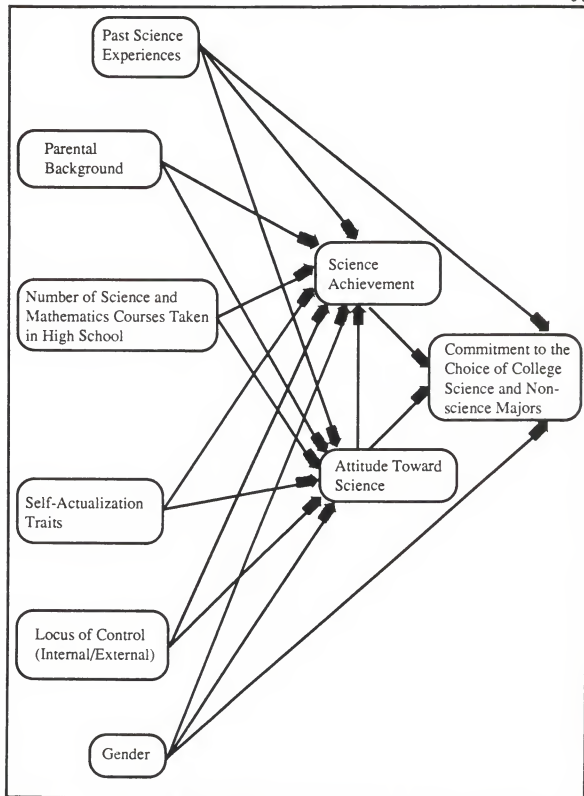


Figure 1. Path diagram of 11th and 12th graders' science achievement, attitude toward science, and beyond high school for a commitment to the choice of college science and non-science majors.

1,622 students, 385 eleventh and 364 twelfth graders and Buchholz high School with a total of 1,793 students, 411 eleventh and 412 twelfth graders. The one high school in the rural area is Santa Fe High School with an enrollment of 877 students, 219 eleventh and 182 twelfth graders. Santa Fe has the largest enrollment of the three rural areas schools.

For this study, 321 subjects were selected from these three high schools. These subjects were enrolled in three different levels of physics and chemistry courses: standard, honor, and advanced placement (AP). The breakdown of students in these courses is shown in Table 1.

Procedures

Permission to carry out the research was obtained in September 1989, from the human subject committee at the University of Florida and from the Alachua County Schools. The researcher, through the Alachua County School's research and testing office, sent a letter to the principals of five of the six existing high schools in the district, informing them of the nature of the project and requesting their participation in this study. Four principals, two from inner city high schools and two from rural high schools, agreed to participate. Once the principals agreed to participate, they provided the researcher with a list of all the teachers of physics and chemistry courses (standard,

Table 1. Profile of the Eleventh and Twelfth Grade High School Student Participation in Physics and Chemistry.

Standard		Honor		Advanced Placement	
		Physics	Chemistry	Physics	Chemistry
Male	37	45	16	20	29
Female	38	64	12	25	15
11th Grade	7	91	7	45	25
12th Grade	68	18	21	4	19
Total		186	73		67

honor, AP) at the eleventh and twelfth grade levels in their schools.

Subsequently, the researcher sent a letter of introduction and explanation of the nature of this project to all teachers from the principals' lists (Appendix A). Later, the researcher made arrangements to see each teacher, to explain the procedure, to answer their questions, and to request their class participation in this project. Five teachers from urban high schools and one teacher from one rural high school agreed to participate.

Prior to the actual testing procedure, the researcher provided parental consent forms to the teachers who agreed to be part of this study for their students to take home to obtain parental permission (Appendix B). Once parents signed the Informed Consent Form and returned it to the teacher, the researcher went to each high school site at a prearranged time for conducting the study. On the designated day of testing for each class, the researcher first distributed the Student Informed Consent Form (Appendix C) and asked each student to read it and, if they would agree to participate, to sign the form. Only three students from the urban high schools and two students from the rural high schools did not agree to participate in this study.

After students signed their informed consents, the researcher passed out the package of questionnaires to

students. Each student received measures of: attitude toward science, self-actualization, the locus of control, and the demographic information. Then, the researcher directed students' attention to the directions that were provided on each questionnaire and on the demographic information sheets. Demographic information can be seen in Appendix D.

At the end of the class period, the researcher collected all of the questionnaires and demographic information. Due to the length of these questionnaires, the researcher returned the following day to the school for completion of the testing procedure. All of the tests were conducted in a classroom of each designated high school for this study. These data were collected at the beginning of academic year 1989, as part of the first phase of data collection.

The researcher obtained the post-test measure of the second phase of testing, Test of Science-Related Attitudes (TOSRA), at the middle of academic year as the second phase of data collection for this study.

Instrumentation

In this study three scales--measures of attitude toward science, self-actualization, and locus of control and demographic information, including past science related experience--were used to measure respectively six predictor

variables and three response variables. The following is a description of each of these scales, in the same sequence given to samples of this study.

Measure of Attitude Toward Science

The response variable of attitude toward science was measured by The Test of Science-Related Attitude (TOSRA), constructed by Barry Fraser (1981), an Australian. This test consists of 70 items and requires students to express their degree of agreement with each statement on a five-point scale consisting of the responses Strongly Agree (SA), Agree (A), Not Sure (N), Disagree (D), and Strongly Disagree (SD). The instrument was developed for secondary students, both in junior and senior high school (Fraser, 1981). The TOSRA is based on five batteries of attitude scales. From these batteries, TOSRA was improved to the final form.

TOSRA was refined in two stages. The first stage involved modifying a pool of items which were written by a group of science teachers and experts in educational measurement. The second stage involved the field testing of a version of TOSRA which consisted of 14 items per each seven scales and the item analysis technique was used to reduce the length of each scale to ten items (Fraser 1977).

The TOSRA was administered to a large sample that consisted of 1,337 students in 44 classes drawn from 11 different schools in Sydney, Australia. The schools provided four typical grades, seventh, eighth, ninth, and

tenth. The sample of schools was not selected on a random basis. The author stated that the sample was carefully selected to cover a variety of socioeconomic and geographic areas of the population of schools in the Sydney metropolitan area.

Scales of TOSRA. The following scale descriptions are drawn chiefly from Fraser (1981) and Klopfer (1971) classification.

Scales #1 and #2. Two sub-scales, the social implication of science (S) and normality of scientists (N). The S/N scale refers to manifestation of favorable attitudes toward science and scientists.

The S scale measures an aspect of the manifestation of favorable attitudes toward science which has been important in science education literature (Zoller & Watson, 1974; Fraser, 1977), namely attitude toward social benefits from scientific progress.

The N scale measures one aspect of manifestation of favorable attitudes toward scientists, namely an appreciation that scientists are normal people (Mead & Metraux, 1957).

Scale #3: Attitude to Scientific Inquiry (I) measures attitude to scientific inquiry as a way of obtaining information about the natural world.

Scale #4: Adoption of Scientific Attitudes (A) refers to open-mindedness, willingness to revise attitude based on new scientific findings.

Scale #5: Enjoyment of Science Lesson (E) involves enjoyment of science learning experiences.

Scale #6: Leisure Interest in Science (L) involves development of interest in science and science-related activities.

Scale #7: Career Interest in Science (C) measures degree of interest in pursuing a career in science.

Validity. A discriminant validity of TOSRA was estimated by intercorrelation among scales. It was found that, for the total sample of 1,337 students, TOSRA Scale intercorrelations were fairly low and ranged from 0.10 to 0.59 with a mean of 0.33. The highest scale intercorrelation occurred between the three scales of enjoyment of science lesson 0.53, leisure interest in science 0.58, and career interest in science 0.59. One might expect that these three scales would be moderately correlated since there would be a tendency for a student who enjoys science lessons to be more likely to have a leisure and career interest in science. But, because all values of scales are different and scale intercorrelations were smaller than the square root of the product of the corresponding scale reliabilities, it is considered

justifiable to maintain all seven TOSRA scales as separate dimensions (Fraser, 1981).

Additional support for the TOSRA validation was obtained by a cross-validation study done in Australia and in the United States. Five new samples of secondary science classes were obtained. The first sample consisted of 712 students in grades 7-9 from 23 different classes, each with a different teacher, in eight different schools in the Sydney suburban area. The next two samples consisted of 567 10-year-old students and 273 12-year-old students in four comprehensive state high schools in Brisbane (Lucas and Tulip, 1980). The fourth sample consisted of 1,041 students who were 8-10 years old, from 11 schools in suburban areas of Perth, Western Australia (Schibeli and McGaw, 1980). The fifth sample consisted of 546 9-year-old students from two suburban Catholic schools in Philadelphia (Fraser, and Butts, in press).

Reliabilities. The internal consistency reliability was estimated for TOSRA scales using the Cronbach α coefficient (Cronbach, 1951). The values of the α reliability coefficients for grades 7-10 were from 0.66 to 0.93. Fraser (1981) asserted that these values for the reliability of scales with only ten items are high. He concluded that these values indicate that each TOSRA scale had quite good internal consistency reliability at each level.

In addition to the internal consistency reliability coefficient, general test-retest reliability was obtained and ranged between .69 and .84 with a mean of .78 over a two week interval.

Measure of Self-Actualization

The predictor variable of self-actualization traits was measured by the Personal Orientation Inventory (POI), developed by Everett L. Shostrom (1964). It is a 150-item two-choice, forced choice statement of value personality traits associated with Maslow's theory of self-actualization. The POI is widely used with adults and young populations. Shostrom (1964) recommended that the inventory should not be used with subjects younger than 14 years of age. The POI can be completed in about 30 minutes.

Scales of POI. The inventory has two major scales: time ratio (time in competence/time competence) and support ratio (other-directed/inner-directed). Time competence is the ability to focus on the present. The self-actualizing person is primarily time competent and appears to live more fully in the here-and-now. He is able to tie the past and the future to the present in meaningful continuity. He appears to be less burdened by guilt, regret, and resentment from the past than is the non-self-actualized person, and his aspirations are tied meaningfully to present working goals. Inner-directed refers to a person's sense of autonomy and independence. The inner-directed person goes

through life apparently independent but still obeying this internal piloting.

In addition to the major scales of time competence and inner-directed, ten sub-scales are designed to measure other aspects of self-actualization.

1. Self-actualizing values (SAV). A high score on this scale suggests that the individual holds and lives by values of self-actualizing people.
2. Existentiality (Ex). It measures one's ability to use good judgment in situations without relying on rigidly held rules or principles.
3. Feeling reactivity (Fr). It measures sensitivity to one's own needs and feelings.
4. Spontaneity (S). It measures the ability to express feelings in spontaneous action.
5. Self-regard (Sr). It measures the ability to like one's self because of worth or strength.
6. Self-acceptance (Sa). It measures affirmation and acceptance of one's self in spite of one's weakness or deficiencies.
7. Nature of man, constructive (NC). Human nature is viewed by self-actualizing people as essentially positive. People can resolve dichotomies in nature such as selfishness, goodness-evil, spirituality-sensuality.

8. Synergy (Sy). It is the ability to transcend dichotomies. It is a measure of the ability to see the opposite in life as meaningfully related.
9. Acceptance of aggression (A). It is a measure of the ability to accept one's anger or aggression within one's self as natural.
10. Capacity for intimate contact (C). It is a measure of the person's ability to develop meaningful, contactful relationships with other human beings (Shostrom, 1966).

Validity. Shostrom (1964) administered the POI to 160 normal, 29 relatively self-actualized, and 34 non-self-actualized individuals. The later two groups had been interviewed and classified by practicing clinical psychologists. The POI significantly discriminates clinically judged self-actualizing persons from non-self-actualizing persons on 11 of the 12 scales.

In another study, Fox, Knapp and Michael (1968) administered the POI to 100 males and females hospitalized for psychiatric problems. These 100 individuals' POI scores were compared with scores of a non-self-actualized sample of 39, a normal sample of 158, and a self-actualized sample of 29. The POI successfully discriminated among these groups. The greatest significance occurred between the hospitalized group and the self-actualized group.

Finally, several authors have reported on the validity of the POI as a good measure of self-actualization (Goldman & Olczak, 1975; Knapp & Comery, 1973; Knapp & Fitzgerald, 1973; Murray, 1966).

Correlating the POI with other personality instruments has also helped establish the validity of this instrument. Knapp (1965) correlated the POI scales with the Eysenck Personality Inventory (EPI), a measure of neuroticism-stability and extraversion-introversion. The EPI and the POI were each administered to a sample of 136 undergraduate college students. Subjects were selected on the basis of scores on the neuroticism to form a "high" neurotic group and a "low" neurotic group. Five scales, including time competence and inner-directed, were negatively correlated with the scores of the neurotic group at the .01 level.

In a study in which psychological health was related to teacher effectiveness, Dandes (1966) administered the POI to 128 teachers. He reported a multiple correlation of .54 between the POI scale and the Minnesota Teacher Attitude Inventory. Armstrong and Lussiev (1966) correlated the POI with the Edwards Personal Preference Schedule (EPPS) and the Cattell Sixteen Personality Factor Questionnaire (16PF) to 71 undergraduate psychology students from a working class Catholic background. A positive correlation was reported between the EPPS autonomy and the POI inner-directed scales, and a negative correlation was reported between EPPS

Abasement and POI inner-directed scale. On the Cattell Test, bright-intelligent and experimental-critical scales correlated with POI support scales.

Reliability. A number of studies have shown that the POI is a reliable instrument. Shostrom (1964) originally reported test-retest reliability coefficients of .91 for the major competence scale and .93 for the major inner-directed scale. The test-retest reliability coefficient was obtained from a sample of 48 undergraduate college students.

Klavetter and Mogar (1967) administered the POI to 48 college students. They reported correlations of .71 and .77 for the time ratio (TR) and support ratio (SR) scales, respectively. The test-retest interval was one week. Subscale reliabilities ranged from .52 to .82.

Ilardi and May (1968) reported test-retest correlations that ranged from .32 to .71 with a median r of .58. The reliability of the two major scales of time competence (TC) and inner-directed (I) was .55 and .71, respectively. They reported significance of all the scales, except Fr, at the .005 level (one-tailed). Ilardi and May (1968) concluded that the findings reported on the POI are well within ranges somewhat comparable to other personality test-retest reliability studies.

Finally, Wise and Davis (1975) administered the POI to 172 university students. The test-retest (two weeks) reliability coefficients for time competence (TC) were .75

and .77 for inner-directed (I). Split-half coefficients were .50 and .84 for time competence and .73 and .87 for inner-directed.

Some researchers have criticized the POI, stating that some of the subscales failed to relate to specific characteristics inherent to actualization (Tosi & Lindamood, 1975). Other researchers discussed the subsequent complexity of scoring and interpreting data due to the large numbers of factors in the POI (Klavetter & Mogar, 1967; Oakland, Freed, Lovekin, Davis, & Camilleri, 1978). However, while there are some valid criticisms of the Personal Orientation Inventory, there have been some one hundred studies using the POI. Researchers have reported positive results and have confirmed the POI's ability to distinguish self-actualizing from non-self-actualizing individuals. The POI appears to be a valid and reliable instrument for measuring the construct of self-actualization.

Measure of External and Internal Locus of Control

The Children's Nowicki Strickland Locus of Control (CNSIC), published by Nowicki-Strickland (1973), was used to measure the locus of control construct. This test is a paper and pencil measure of the locus of control measure consisting of 40 questions that are answered by checking either yes or no. The final form of the scale derived from 102 items which was based on Rotter's definition of the

internal-external control of reinforcement dimension. The 102 items along with Rotter's definitions of the locus of control dimension were given to a group of clinical psychology staff members ($N = 9$) who were asked to answer the items in an external direction. Items were dropped when there were disagreements among the judges; this resulted in 59 items remaining. The 59 items were then given to a sample of 152 children, ranging from third through ninth grades. Test-retest reliabilities for a six week period were .67 for the 8-11 year old group and .75 for those in the 12 to 15 year old group. Item analysis was computed to examine the discriminative performance of the items. The result of this analysis, along with comments from teachers and pupils in the sample led to the present scale consisting of 40 items (Nowicki and Strickland, 1973). This scale is appropriate for children from ages 9 through 18.

Validity. A prime goal of those who construct a locus of control scale is to keep social desirability response at a minimum. Nowicki and Strickland (1973) reported nonsignificant correlations between locus of control scores and social desirability for subjects in grades three to twelve. Intelligence is another variable that should not be related to locus of control scores. Nowicki and Strickland (1973) and Nowicki and Roundtree (1971) reported that no significant correlations were found between the CNSIE scores and IQ scores.

As added support of convergent validity for the CNSIE, Nowicki and Strickland (1973) reported data showing a moderate relationship with other measures of locus of control. The Intellectual Achievement Responsibility Scale (Crandall, Katkovsky, and Crandall, 1965) was correlated with the CNSIE. A significant correlation was found with the CNSIE but not the Intellectual scores, with 182 black students in third and 171 seventh graders.

For evidence of construct validity of the CNSIE, some studies collected data on the major areas of demographic, achievement competence, and personality characteristics. Nowicki and Strickland (1973) reported a significant relation between CNSIE scores and social class, with the higher social class being internal.

In terms of race, it has been found that blacks scored more externally than whites (Marcus, 1975; Nowicki, 1976; Fryrear & Carlson, 1976). Indians also have been found to score more externally than whites (Tyler & Holsinger, 1975).

There are a number of studies that support the theoretical assumption that internality is associated with academic achievement, and persistence. Nowicki and Strickland (1973) reported a significant correlation between internality and higher academic achievement for children from grades three through 12. A number of studies reported, as would be expected, that internals persisted longer on

tasks than did externals (Gordon, 1977; Short, 1976; Bloodworth, 1975; Weiner, 1975; Waters, 1971).

Finally, locus of control has been related to other personality variables. For example, internality has been related to higher self-esteem (Gordon & Wilbur, 1974; Roberts, 1971) and to higher self-concept (Cervantes, 1976; Morris, 1976).

Reliability. Nowicki and Strickland (1973) reported test-retest reliabilities sampled at three grade levels: .63 for 99 third graders, .66 for 117 seventh graders, and .71 for 125 tenth graders, in six weeks apart. These figures were approximated in twelfth graders (Nowicki and Roundtree, 1971) who showed a test-retest reliability of .76 over five weeks.

Thomas (1973) reported a significant test-retest reliability over a one year period for the CNSIE with a sample of 457 institutionalized children, ranging from 7-14 years old. Likewise, Anderson (1976) reported a test-retest reliability of .67 for 80 students in grades 3 and 4 for a six month period.

Although Rotter's (1966) locus of control scale has been the most widely used, it appears most appropriate for college-aged and educated subjects. However, the CNSIE is the only locus of control measurement device derived from the work of Rotter which is appropriate for children from ages 9-18 years. A number of investigators have reported

significant findings when they correlated the psychological and educational variables with the locus of control construct. These studies have used the Children's Nowicki and Strickland locus of control measure (LeCourt, 1983).

Data Recording

The researcher obtained information from the students on the demographic survey about their science-related information and their family background. This information was organized on survey data sheets designed by the researcher. A copy of the data information sheet can be found in Appendix D.

Independent Variables

Students and Their Family Variables

The student's information was gathered by data sheets designed by the researcher. Variables gathered were age sex, grade, school, parents' education level, and parents' occupations. These variables were a part of the predictor variables in this study.

Student Past Science Activity-Related Variables

In this study, information on student's past science activities and interest in science were treated as predictor variables. This information was obtained by means of several questions developed by the researcher from literature on science education and specifically from Kahle

and Lakes (1983) research on student background science activities. The questions were asked pertaining to student's science-related activities in preschool, elementary, junior high school, and related information to students' extracurricular activities.

Number of Science and Mathematics Courses Taken in High School

Number of science and mathematics courses taken in high school was treated as a predicted variable. This information was obtained by data sheets on which students listed the science and mathematics courses that they had taken in high school.

Dependent Variables

Science Achievement Variable

Science achievement in this study was treated as one of the response variables. This variable was measured by the teacher assigned grade each student received on his physics or chemistry course at the end of the fall term.

Commitment to a Science and Non-Science Major for College Variable

Student commitment to science and non-science for an intended major in college was treated as a response variable. Information on students' commitments to intended majors was recorded on a data sheet developed by the researcher. This information pertains to students' plans after high school graduation, if they plan to go to college

or a university, what would be their choice of a major, and students were asked what factors influenced their choice.

Research Questions

The following questions have been developed to determine the impact of predictor variables, as shown in Figure 1, on response variables of science achievement, attitude toward science, and commitment to choice of majoring in science and non-science.

1. Is there a significant impact of past science experiences of eleventh and twelfth grades on science achievement, attitude toward science, and commitment to the choice of majoring in science or non-science?
2. Is there a significant impact of parental background of eleventh and twelfth grades on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?
3. Is there a significant impact of number of science and mathematics courses taken in high school on eleventh and twelfth grade students science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?

4. Is there a significant impact of self-actualization traits, locus of control construct of eleventh and twelfth grade students on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?
5. Is there a significant impact of gender on eleventh and twelfth grade students on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?
6. Is there a significant impact of science achievement, and attitude toward science of eleventh and twelfth grade students on their commitment to the choice of majoring in science and non-science?
7. Is there a significant difference between scores of pretest and posttest of eleventh and twelfth grade students attitude toward science, as measured by the Test of Science-Related Attitudes (TOSRA)?

Data Analysis

The data were analyzed by using descriptive and inferential statistical techniques. The Pearson Correlation was used to determine significant relationships between

variables of interest. Then path analysis and causal modeling are applied. Asher (1976) stated that one main advantage of using path analysis is that it enables the researcher to determine the direct and indirect effects that one variable has upon another in an operative causal mechanism. The author states that causal modeling "is a technique for selecting those variables that are potential determinants of the effects and then attempting to isolate the separate contributions to the effects made by each cause [predictor variable]" (Asher, 1976, p. 5). In this study, path analysis and causal modeling were used to assess first the magnitude of effect of six predictor variables on two response variables: science achievement and attitude toward science.

Second, path analysis and causal modeling was used to assess the impact of the two response variables on the third response variable, commitment to choice in science and non-science major. This will yield the indirect path to commitment to choice in science (see Figure 1).

Third, a direct path also was determined. Path analysis and causal modeling were used to measure the impact of six predictor variables on the response variable commitment to a science and non-science majors. This analysis will yield data on the direct impact of each predictor variable on one response variable, commitment to college science major.

The findings of the study are reported in Chapter 4 of this dissertation, and discussion of findings, implications, and suggestions for further research are presented.

CHAPTER 4

RESULTS

The purpose of this study was to investigate the influence of parental background, student's background, gender, and certain personality traits on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science. The scales selected to explore the variables of interest were the Children's Nowicki-Strickland Locus of Control Scale (CNSIE), measuring internal and external locus of control; the Personal Orientation Inventory Scale (POI), measuring self-actualization; and the Test of Science-Related Attitudes Scale (TOSRA), measuring attitude toward science. Demographic data were also obtained to analyze selected characteristics of high school students.

In this chapter the statistical results of the study are presented. First, the demographic information regarding the sample is provided. Second, the relationships among variables that were determined by correlation analyses are delineated. Third, gender differences in the model variables are presented. Fourth, responses to research questions that were revealed in the causal model are

reported. Finally, the overall results of the study are summarized.

Information about the Sample

The sample in this study was a group of male and female adolescents who were enrolled in three different levels of physics and chemistry courses (standard, honor, and advanced placement). There were 321 students from eleventh and twelfth grade classes in three high schools in Alachua County, Florida. Of these participants, 55.5% were from eleventh grade and 44.5% were twelfth graders (see Table 2).

Table 2. Frequency and Percent by Gender and Grade.

	Males		Females	
	N	Percent	N	Percent
Total	160	49.8	161	50.2
Grade				
11th	85	53.1	93	57.8
12th	75	46.9	68	42.2

Parent's Level of Education

The education level of the subjects' parents was recorded according to parent completion of the following school levels: high school, college, graduate school (M.S.,

~~school levels: high school, college, graduate school~~ (M.S., Ph.D.), and medical education. As Table 3 indicates, the parents' appeared to be highly educated individuals.

Table 3. Parents' Level of Education.

	Father		Mother	
	N	Percent	N	Percent
High School	67	21.8	81	25.4
College	91	29.6	139	43.6
Masters	54	17.6	73	22.9
Ph.D.	53	17.3	11	3.4
Medical Professional	26	8.5	11	3.4
Law Professional	10	3.3	1	0.3
Other	6	2.0	3	0.9

Parents' Occupations

Table 4 displays parents' occupations according to selected areas. There is a difference between number of fathers in professions related to engineering than mothers. Also, the number of fathers engaged in business (N = 88) is double the number of mothers (N = 40). More mothers, however, were teachers (N = 52) than were fathers (N = 18). In summary parents' educational level were similar but their occupations split along gender lines.

Table 4. Occupations of Students' Parents.

	Father		Mother	
	N	Percent	N	Percent
Engineering	21	7.2	1	0.4
University and College Professor	43	14.7	21	8.3
Physician, Medical Profession	39	13.3	38	15.1
Attorney	7	2.4	2	0.8
Business	88	30.0	40	15.9
Governmental Position	30	10.2	16	6.3
Teacher, Education-Related Profession	18	6.1	52	20.3
Office Employee	8	2.7	49	19.4
Laborer	18	6.1	10	4.0
Other	21	7.2	23	9.1

Relationships Between Variables

Correlation analysis between all variables in the path model was accomplished by using Pearson Product Moment. A summary of these correlations is presented in Table 5. The past science experiences and number of science and mathematics courses taken in high school were significantly correlated with several variables in the model.

The past science experiences are positively correlated with the number of science and mathematics courses in high school ($r = 0.131$, $p = 0.018$). The more science experiences students had in the past, the more science and mathematics courses they took in high school. Past science experience was also significantly correlated with attitudes toward science ($r = 0.368$, $p = 0.0001$). This suggests that a student's past science experiences are related to a student's current attitude toward science. This relationship supports findings by the researchers. To the contrary, past science experience had a negative association with locus of control ($r = -0.154$, $p = 0.0005$). The number of science and mathematics courses taken in high school was significantly correlated with gender ($r = 0.180$, $p = 0.012$). The number of science and mathematics courses taken in high school was also significantly correlated with locus of control and science achievement, but in an inverse relationship ($r = -0.194$, $p = 0.005$; $r = -0.204$, $p = 0.003$). On the contrary, the

Table 5. Intercorrelations Between All Variables.

Variables	1	2	3
1. Parental Background	1.000	-0.041	0.004
2. Past Science Experience		1.000	0.131*
3. Number of Science and Mathematics Courses Taken in High School			1.000
4. Gender			
5. Self-Actualization Traits			
6. Locus of Control			
7. Attitude Toward Science			
8. Science Achievement			
9. Commitment to Choice of College Major in Science and Non-Science			

* = Significant at .01 level.

** = Significant at .05 level.

Table 5--Extended

4	5	6	7	8	9
0.027	0.024	0.018	0.279	0.038	-0.017
0.056	0.035	-0.154**	0.368**	0.021	0.065
0.180**	-0.224	-0.194**	0.320**	-0.204**	-0.162**
1.000	-0.097	-0.073	0.102	0.000	-0.170**
	1.000	-0.136*	0.020	0.0041	0.097
		1.000	-0.249**	0.134*	0.053
			1.000	-0.109	0.226**
				1.000	0.066
					1.000

number of science and mathematics courses taken in high school was positively correlated with attitude toward science ($r = 0.320$, $p = 0.001$). This positive correlation was fully expected since it is known that students who take more science and mathematics courses in high school tend to have a positive attitude toward science.

Among the psychological variables in the model, an attitude toward science was the only one to be significantly related to commitment to choice of majoring in science and non-science ($r = 0.266$, $p = 0.001$). This positive relationship between these two variables indicates that a student's current attitude toward science may influence his/her choice of commitment. The strongest correlation from this data, however, was noted between students' past science experiences and their attitudes toward science ($r = 0.368$, $p = 0.001$). The second strongest correlation was between number of science and mathematics courses taken in high school and attitudes toward science ($r = 0.320$, $p = 0.001$). Caution is needed in interpreting these findings. However, students' attitudes toward science can be shaped depending on how much they have previously been exposed to science and how many science and mathematics courses they took in high school.

Gender Differences

Table 6 presents the means for males and females by major, background, and psychological variables in the path model. Males and females scored very close on most variables. Gender differences are significantly evident in one of the background and one of the psychological variables. Males scored higher than females on the number of science and mathematics courses taken in high school. Males have taken more courses in these subjects than their female peers in high school.

In the pretest and post, attitudes toward science, males had a higher mean score than did females. On the post-test, males' attitudes toward science scores were significantly higher than the female scores. There was not a significant gender difference on the mean scores of other psychological variables. Self-actualization traits were not found significant in variables of the model, but there was a significant gender difference found in seven of fourteen scales of the POI. Interestingly, females' mean scores were significantly higher than males in five scales and males' scores were significantly higher on two of the POI scales (see Table 7).

In the following scales of the POI, the mean scores of females were significantly higher than of the males: Inner-Directedness, Feeling Reactivity, Nature of Man, Synergy, and Acceptance of Aggression (see Table 7). Males had

Table 6. Means and p Value for Variables by Sex.

Variables	Males (N = 161)	Females (N = 160)	P
Parental Background	12.54	12.15	0.428
Past Science Experiences	11.52	11.73	0.691
Number of Science and Mathematics Courses Taken in High School	16.92	14.31	0.001*
Self-Actualization Traits	75.89	77.75	0.081
Locus of Control	15.08	15.90	0.265
Attitude Toward Science (Pretest)	252.39	245.92	0.068*
Attitude Toward Science (Posttest)	243.14	234.67	0.026*
Science Achievement	3.26	3.20	0.992
Commitment to Choice of College Science Major	5.95	5.22	0.022*

* = Significant at .05 level.

Table 7. Means and Standard Deviations of Personal Orientation Inventory (POI) Scores by Sex.

	Males (160)	
	Means	Standard Deviation
Time Incompetence (Ti)	9.73	2.84
Time Competence (Tc)	13.43	2.71
Other-Directedness (O)	49.60	9.44
Inner-Directedness (I)	75.10	10.67
Self-Actualization Values (SAV)	19.38	3.27
Existentiality (Ex)	17.99	3.98
Feeling Reactivity (Fr)	14.00	3.17
Spontaneity (S)	11.90	2.47
Self-Regard (Sr)	11.97	2.37
Self-Acceptance (Sa)	12.96	2.96
Nature of Man (No)	11.16	2.13
Synergy (Sy)	6.36	1.40
Acceptance of Aggression (A)	15.63	3.27
Capacity for Intimate Contact (C)	16.61	3.53

* = Significant at 0.01 level.

Table 7--Extended

Females (161)		
Means	Standard Deviation	P
8.85	3.19	0.009*
14.07	3.13	0.012*
47.49	9.46	0.024*
78.12	10.21	0.020*
19.81	2.99	0.241
18.33	4.13	0.308
15.63	3.18	0.008*
12.16	3.68	0.466
12.11	2.32	0.584
13.26	2.95	0.365
11.68	1.71	0.017*
6.86	1.49	0.001*
16.33	3.07	0.047*
16.76	3.57	0.554

significantly higher scores than did females on Scales of Time Incompetence and Other-Directedness.

Males and females' differences in their commitment to choice of majoring in science and non-science after high school graduation is evident. As Table 8 displays, a higher proportion of males (48.8%) committed to science majors than did females (30.4%). Furthermore, males and females were found to differ in their specific choice of science majors for college. Table 9 indicates that more males selected engineering (31.9%) and physical science (8.8%) than did females, engineering (8.8%) and physical science (3.5%). However, a slightly higher percentage of females selected biological science (30.1%) than did males (27.7%). The result of gender differences in choice of science majors appears to follow the trend of findings of other studies. More males choose engineering and physical science than do their female peers.

Table 10 shows the mean of major variables in the model for both females and males who are committed to the choice of science or non-science majors. The past science experience was significant ($p = 0.006$) in favor of females who committed to science majors. The number of science and mathematics courses taken in high school variable was significant for both males and females ($p = 0.0102$).

Table 8. Frequency and Percentage of Commitment to Choice of College Majors by Sex.

	Males (N = 160)		Females (N = 161)	
	N	Percent	N	Percent
Commitment to Science Majors	78	48.8	49	30.4
Commitment to Non-science Majors	33	20.6	66	41.0
Undecided Major	49	30.6	46	28.6

Table 9. Frequency and Percentage of Choices of College Majors by Sex.

Choice of College Major	Males (N = 111)		Females (N = 115)	
	N	Percent	N	Percent
Engineering	36	31.9	10	8.8
Physical Sciences	10	8.9	4	3.5
Biological Sciences	31	27.7	35	30.1
Social Sciences	6	5.4	12	10.6
Education	1	0.9	16	14.2
Business	20	17.9	14	12.4
Humanities	2	1.8	10	8.8
Computer Science	2	1.8	4	3.5
Other	3	2.8	10	9.3

Table 10. Means of Variables for Commitment to Choice of Science Majors and Non-Science Majors by Sex.

	Males		Females	
	Committed to Science Majors (N = 78)	Committed to Non-Science Majors (N = 33)	Committed to Science Majors (N = 49)	Committed to Non-Science Majors (N = 66)
Parental Background	12.52	12.44	11.16	12.56
Past Science Experiences	12.35	12.26	12.93	11.09
Number of Science and Mathematics Courses Taken in High School	16.91	14.55	16.50	13.66
Self-Actualization Traits	75.84	76.94	77.60	77.96
Locus of Control	15.17	15.70	16.20	15.83
Attitude Toward Science (Pretest)	262.92	235.79	259.02	234.23
Attitude Toward Science	251.56	228.79	248.54	227.22
Science Achievement	2.97	3.82	2.87	3.28

The pretest of attitudes toward science was significant ($p = 0.0001$) for both males and females committed to science majors. The posttest of attitudes toward science was also significant ($p = 0.0001$) for both males and females who committed to science majors.

The gender differences were also found in the classes of the study with the variables in the model. As Table 11 shows, mean value of males and females in some classes differs in respect to four major variables. In the past science experience variable, males have a higher value than females on AP physics and AP chemistry, while females have a higher mean score on honor physics, chemistry, standard physics, and standard chemistry. In the number of science and mathematics courses taken in high school, male students in AP physics, honor physics, and standard chemistry have a higher mean score than females in these classes. Males and females in other classes have a very close mean score in respect to their number of science and mathematics classes in high school.

In attitude toward science, males in AP physics and standard chemistry have a higher mean score. Females in AP chemistry and honor chemistry have a higher mean attitude score.

In posttest attitudes toward science, despite the fact that both genders' attitude declined, males in AP physics, honor chemistry, and standard chemistry have a higher mean

Table 11. Means of Variables by Class and Sex.

Variables	AP Physics		AP Chemistry	
	Males	Females	Males	Females
Parental Background	14.31	13.14	11.96	10.86
Past Science Experiences	12.87	10.42	13.35	12.80
Number of Science and Mathematics Courses Taken in High School	23.43	22.00	21.06	21.86
Self-Actualization Traits	78.12	76.00	71.58	73.86
Locus of Control	14.62	17.14	14.48	13.93
Attitude Toward Science (Pretest)	273.00	264.85	265.25	271.20
Attitude Toward Science (Post-test)	270.75	261.00	258.25	260.57
Science Achievement	2.35	3.42	3.41	2.46
Commitment to Choice of Science and Non-Science Majors	5.42	4.25	5.73	4.77

Table 11--Continued

Variables	Honor Physics		Honor Chemistry	
	Males	Females	Males	Females
Parental Background	11.33	13.08	11.00	11.47
Past Science Experiences	10.06	12.83	11.44	12.39
Number of Science and Mathematics Courses Taken in High School	19.66	17.75	19.00	18.56
Self-Actualization Traits	73.73	79.33	80.61	82.13
Locus of Control	13.93	15.33	15.55	14.21
Attitude Toward Science (Pretest)	250.80	250.41	252.22	254.21
Attitude Toward Science (Post-test)	239.73	243.91	253.58	242.27
Science Achievement	3.26	3.50	3.72	3.18
Commitment to Choice of Science and Non-Science Majors	6.33	5.62	4.8	6.56

Table 11--Continued

Variables	Standard Physics		Standard Chemistry	
	Males	Females	Males	Females
Parental Background	13.97	13.21	12.09	11.81
Past Science Experiences	10.94	11.67	10.74	11.23
Number of Science and Mathematics Courses Taken in High School	13.00	12.94	13.16	10.35
Self-Actualization Traits	74.94	76.89	77.79	77.49
Locus of Control	15.65	15.45	15.39	17.18
Attitude Toward Science (Pretest)	247.34	247.23	240.53	233.52
Attitude Toward Science (Post-test)	230.54	231.16	230.70	223.58
Science Achievement	3.10	3.14	3.39	3.12
Commitment to Choice of Science and Non-Science Majors	5.62	4.20	4.10	3.68

score. Females only in AP chemistry have a higher attitude mean score.

A gender difference was found between students committed to science and non-science majors in their choice of courses of greatest interest in high school. A higher proportion of males than females choosing science majors reported having interest in physics, chemistry, and mathematics. However, both males and females committed to the science majors reported more interest in physical science and mathematics than did non-science majors. Interest in biology was shared nearly equally by those committed to science majors (see Table 12).

Causal Model

In causal modeling, the variability of a dependent variable is explained through the use of information from one or more independent variables. For each independent variable there is a path coefficient showing the amount of influence in the dependent variable. The coefficients are obtained from ordinary least squares regression.

In this study, a direct causal path model was employed to determine the influence of six independent variables--background, gender, and psychological variables--on three dependent variables--science achievement, attitude toward science, and commitment to choice of majoring in science and

Table 12. Frequency and Percentage of Students Who are Committed to Science Majors and Non-Science Majors for the Most Interesting Course Taken in High School by Sex.

Courses	Males			
	Committed to Science Majors		Committed to Non-Science Majors	
	N	Percent	N	Percent
Physics	35	45.5	8	24.2
Chemistry	46	59.0	15	45.5
Biology	34	43.6	12	36.4
Mathematics	27	34.6	11	33.3
Language	5	6.4	4	12.1
Social Studies	15	19.2	11	33.3
Humanities	6	7.7	6	18.8
General	7	9.0	0	0

Table 12--Extended

Females			
Committed to Science Majors		Committed to Non-Science Majors	
N	Percent	N	Percent
10	20.4	5	7.6
30	61.2	18	27.3
33	67.3	40	60.5
16	32.7	13	19.7
13	26.5	25	37.7
7	14.3	13	19.7
3	6.1	15	22.9
3	6.1	6	9.1

non-science. In the analysis of the data, a series of multiple regression equations was calculated using the SAS statistical package to determine the impact of independent variables on dependent variables. Figure 2 contains a path diagram of the model with relationships of all variables in the study with the respective estimated standardized coefficients and residual coefficients. The effect of each independent variable in the model on the dependent variables will be explained separately according to the research questions.

Research Questions

1. Is there a significant impact of past science experience of eleventh and twelfth graders on science achievement, attitude toward science, and commitment to choice of majoring in science or non-science?

As predicted, the past science experience had a direct impact on commitment to the choice of majoring in science and non-science. Past science experiences were found to significantly influence commitment to the choice of majoring in science and non-science ($p = 0.0186$) and had a greater influence on attitude toward science ($p = 0.0001$). This influence indicated a positive relationship between past science experiences and students' current attitudes toward science.

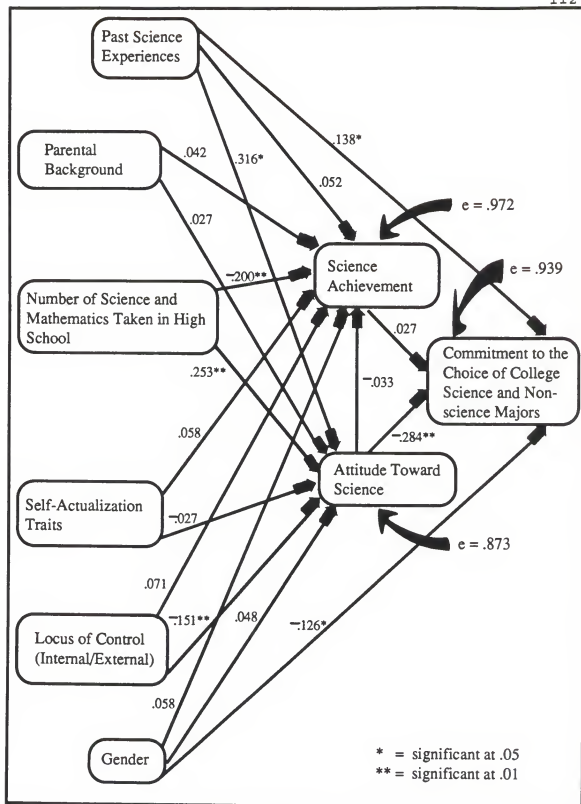


Figure 2. Path diagram with estimated coefficients.

2. Is there a significant impact of parental background of eleventh and twelfth graders on science achievement, attitude toward science, and commitment to choice of majoring in science and non-science?

Parental background, parent educational level and occupation were not found to significantly influence any of the dependent variables. Neither parent education level nor occupation had any impact on the dependent variables.

3. Is there a significant impact of the number of science and mathematics courses taken in high school on eleventh and twelfth grade students' science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?

The number of science and mathematics courses taken in high school had a significant influence on science achievement and attitude toward science (see Figure 2). The negative path coefficient between the number of science and mathematics courses taken in high school and science achievement was due to the method of coding (high school grades used as the achievement variable were coded A = 1, B = 2, etc.).

4. Is there a significant impact of self-actualization traits, locus of control construct of eleventh and twelfth grade students on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?

The self-actualization traits did not significantly influence any dependent variables. This finding was probably the result of multi-collinearity with other intervening factors. The locus of control construct had a significant positive influence on attitude toward science ($p = 0.0035$).

5. Is there a significant impact of gender on eleventh and twelfth grade students on science achievement, attitude toward science, and commitment to the choice of majoring in science and non-science?

In the model, gender was one of the independent variables which had a direct impact on commitment to choose science and non-science majors.

6. Is there a significant impact of science achievement and attitude toward science of eleventh and twelfth grade students on their commitment to the choice of majoring in science and non-science?

The attitude toward science was found to have a significant influence only on commitment to the choice of majoring ($p = 0.0001$). It is unclear, however, if negative or positive attitude toward science value would have a different impact on commitment to the choice of major in science and non-science.

The result of the research questions, as noted, indicates that not all independent variables in the path model had a significant influence on the response variables. Three variables, however, were shown to have a strong significant influence. Two independent variables with the greatest influence were past science experiences (.316) on attitudes toward science, and the number of science and mathematics course taken in high (.253) on attitudes toward science. The dependent variable of attitudes toward science (-.284) had a direct influence on commitment to choice of majoring in science and non-science. Also, the indirect effects were computed. None of them were statistically significant.

Next, those coefficients which were not statistically significant at .05 level of significance were eliminated. Figure 3 shows the reduced path diagram which all the estimated paths coefficients were statistically significant at .05 level.

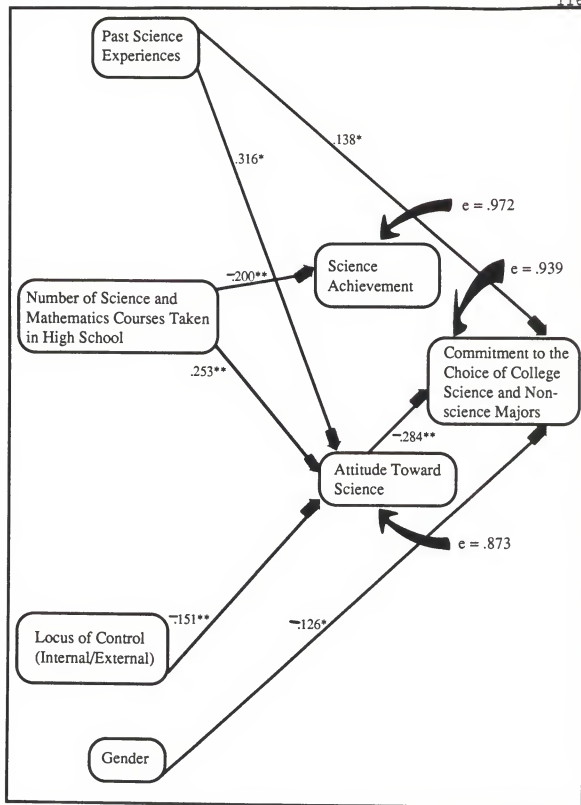


Figure 3. Reduced path diagram with significant estimated coefficients.

Pretest and PostTest Measure of Attitude Toward Science

The last research question of the study was related to students' attitude toward science. In order to assess a significant change in students attitude, the Test of Science-Related Attitudes (TOSRA) was administered at the beginning and the middle of the academic year. There was an overall significant difference in mean score of TOSRA for all students at the middle of the year. Students' attitude changed negatively. However, males' attitudes declined slightly more at posttest than did the attitude of female student peers (see Table 13).

Summary

The analyses of Pearson Product Moment Correlations between variables of this study indicated that a number of variables were significantly correlated. Particularly, three variables, past science experiences, number of science and mathematics courses taken in high school, and attitude toward science, were significantly related to other variables in the path model. There were also significant differences by gender found between the major variables in the path model. These gender differences were greater in major variables in the model between males and females who are not committed to non-science majors. Students who committed to the choice of science majors had a higher mean value.

Table 13. Means, P Value for Pretest and Post-test Scores on the TOSRA Scales by Sex.

Subscales	Pretest		Post-test		P
	Males	Females	Males	Females	
Social Implication of Science	39.48	39.29	34.98	35.51	0.396
Normality of Scientists	35.70	36.79	34.98	35.51	0.321
Attitude to Scientific Inquiry	36.69	35.28	34.64	34.11	0.412
Adoption of Scientific Attitude	38.72	39.29	37.22	37.20	0.648
Enjoyment of Science Lessons	36.73	34.90	35.12	33.18	0.030*
Leisure Interest in Science	33.18	30.77	32.14	29.15	0.005*
Career Interest in Science	33.87	30.40	32.98	29.51	0.001*

*Significant at .05 level.

variables. However, two independent variables, parent background and self-actualization traits, were found to have no significant influence. The number of science and mathematics courses taken in high school and attitude toward science had the strongest influence on the dependent variables in the path model.

CHAPTER 5 CONCLUSIONS

This chapter contains a summary of the background, purpose, and procedures of the study. The findings are then discussed. Implications and direction for future research and conclusions are then presented.

Summary of the Study

In recent years it has been noted that fewer students take science courses in high school and fewer students enter science-related careers. Factors influencing students' interest in science or non-science majors are many and varied. A causal model was constructed to investigate the influence of selected independent variables of parental background, students' science background, self-actualization traits, locus of control, and gender on the dependent variables of science achievement, attitude toward science, and subsequently the impact of all these variables on the high school students' commitment to the choice of science and non-science majors. In order to study a causal relationship between these variables, a volunteer sample of 320 eleventh and twelfth grade students was obtained. These

subjects were drawn from two urban high schools and rural high school in Alachua County, Florida.

Participants each completed three questionnaires and demographic information which were pertinent to the research variables of interest. The student science background, parental background, and commitment to the choice of science and non-science majors were collected in demographic information. The self-actualization traits were measured by the Personal Orientation Inventory (Shostrom, 1964). Locus of control was measured by the Children's Nowicki-Strickland Locus of Control (Nowicki-Strickland, 1973). The student attitude toward science was measured by the Test of Science-Related Attitude (Fraser, 1981). The measure of student achievement in science was semester grades assigned by the instructor.

The data were analyzed by using descriptive and inferential statistical measures. The Pearson Product Moment correlations was used to determine which variables were significantly related. Then path analytic techniques, using the SAS statistical package, were applied to determine the causal relationships between the independent and dependent variables of the study.

Findings from the causal model indicated that the independent variables of students' past science experiences, number of science and mathematics courses taken in high school, locus of control, and gender impacted selected

dependent variables of science achievement, attitude toward science, and students' commitment to the choice of science and non-science majors. Two independent variables of parental background and self-actualization appeared to have no significant influence, and therefore, were excluded from the path diagram.

Discussion

Discussion of this study is organized according to the sequence of findings. This discussion contains three sections: (a) correlation results, (b) findings discussed in terms of gender differences, and (c) causal model.

Correlation Results

Past science experiences, number of science and mathematics courses taken in high school, and attitude toward science had the highest correlations among variables of the study. Past science experience was found to be significantly correlated to both number of science and mathematics courses taken in high school and students attitude toward science. The results support the view expressed in Chapter 2, Survey of the Literature, that the number of science experiences appears to be a valid indicator of student's commitment to taking science and mathematics courses in high school. In addition, students who had more background in sciences tended to have a more positive attitude toward science than did students who had

limited exposure to science experience. These findings support the notion that lack of experience in science appears to be a contributing factor to negative attitude toward science (Kahle & Lakes, 1983).

The number of science and mathematics courses taken in high school was also positively correlated with student current attitudes toward science. This significant relationship found between two of these variables indicated that the number of science and mathematics courses students taken in high school might play an important role in these students developing a positive attitude. Caution is in order since all or none of these explanations is possible.

Attitude toward science was also found to be significantly associated with students' commitment to the choice of science and non-science majors. The significant link found between two of these variables suggests that students' choice of commitment for career could be determined by the type of attitude students have formed toward science. For example, it was suggested that female students tended to have a negative attitude toward physical science and engineering courses. Because of this negative attitude female students may avoid these fields for choice of career. This supports Kahle and Lakes (1983) report that females do not often choose science, especially physical science and engineering, as their choice of college majors.

Gender Differences

Striking gender differences were revealed in the variables of interest. Male students had higher mean scores in the variables of number of science and mathematics courses taken in high school, and pretest and posttest attitude toward science than female students had. Male students took more science and mathematics courses in high school than did their female peers. This is similar to findings of other researchers (Berryman, 1983; Campbell & McCabe, 1982; Duntman, 1979). The fact that female students completed fewer high school courses in science and mathematics than did males may contribute to their choice of a major in college. Likewise, their attitude toward science plays a major role for underrepresentation of females in science courses and careers (Kelly, 1981).

Statistically significant differences were noted between male and female student's pretest and posttest scores of attitude toward science. Overall, students had lower mean scores on the posttest following their experience in science class. However, significant differences for male students were found on subscales: the enjoyment lesson, leisure interest, and career interest on pretest and posttest. For females, the only significant difference was found on the subscale of normality of scientists at pretest. Females' positive attitude toward scientists changed after having science course experience for one semester. Females'

perception of scientists perhaps changed as they associated their experiences in the science class with their view that scientists are odd and their work is carried out in isolation from other people (Farmer, 1987).

These results of gender differences on attitude toward science, in favor of males, concur with previous research findings that reported males tended to have a more positive attitude toward science than did female counterparts (Baker, 1983; Fish, 1979; Handley & Morse, 1983; Peterson et al., 1980; Ward, 1979).

Findings of the current study also concur with the results of previous researchers who reported that a higher proportion of female students did not choose science majors considered to belong to the male domain (Fox, 1981; Hayenga & Hayenga, 1979; Kahle & Lakes, 1983). Furthermore, the results were similar to findings in the literature that suggest a significant number of male students tend to choose engineering and physical science majors, whereas females choose biological science majors.

Interestingly, the results showed a substantial number of females of this study chose education and business as their college majors. The fact that a large number of female students chose education as a major indicated that female traditional career choices are still in demand while females' interest in business careers is emerging. Female students are expanding their career interests, but this

shift of career interest tends to focus more on non-scientific careers. Females have gained in the number who choose science at the college level. In a 1985 study, however, only 30% of college-bound high school women, compared to 50% of their male counterparts, intended to study science and engineering in college (Kahle, 1985).

There are a number of barriers identified in the literature that impacted young women's plans for not participating in science careers. McClure and Piel (1978) reported that a nationwide sample of high school girls stated that they felt scientific careers are incompatible with family life. More recently, Matyas (1986) suggested that female college students' anticipation of science-oriented majors is closely linked to their identification with traditional sex roles.

Female students' scores were statistically significant on six POI scales, and male students' scores were significant on two POI scales. These results are in agreement with other researchers' findings that suggest female students, as a group, may score higher on POI scales than do males (Gibb, 1966; Murphy, 1975; Otten, 1977).

On the Other-Directedness (O) scale, only male scores were found to be statistically significant. The O scale measures the extent the individual is influenced primarily by the need and wishes of others. The male students of this study appear to conform to wishes of others; the societal

and educational system puts heavy expectations on males to succeed in their education plans and goals. Females seem to not respond to the same demands. Female students also scored significantly higher on mean score of the Feeling Reactivity (Fr) scale than did their male student peers. The Fr scale measures sensitivity to one's own needs and feelings. This provides additional evidence that females in science classes are self-actualizing.

Existentiality (Ex) measures the extent to which one is able to use good judgment in situations without relying on rigidly held rules of principle. Spontaneity (S) measures the freedom to be oneself. Theoretically, the individual who scores low on either of these scales tends to be Other-Directed. The results of this study tend to support this only for male students.

Shostrom (1974) indicated that when a quick estimate of self-actualization is desired, only the Time-Competence and Inner-Directed scales of POI may be scored. From the POI mean scores obtained in this study, female students' scores were statistically significant on these two scales. Additionally, their mean scores were significant on the other four scales of Feeling Reactivity, Nature of Man, Synergy, and Acceptance of Aggression. These results on the POI indicated that female students who were enrolled in

science courses appear to demonstrate a higher level of self-actualization than their male student counterparts.

A gender difference in favor of males was found between students enrolled in AP. The male students had higher mean scores on variables of past science experience, number of science and mathematics courses taken in high school, and their attitude toward science than did female students. The more extensive science background that male students had in AP classes provided them with strong science foundations. They tended to be in a better position to choose scientific careers such as the physical science and engineering fields.

There were gender differences in respect to number of science and mathematics courses taken in high school and students' attitude toward science, in favor of males, in AP and honor classes. These findings support the findings of Kahle and Lakes (1983): females by age 17, about the time of high school graduation, have taken fewer courses in both mathematics and physical science and have a negative attitude toward science careers.

Causal Model

In order to fully assess the influence of predictor variables or response variables of interest, a causal model was employed. Results from this study suggest a causal relationship between a number of variables, as was hypothesized. Findings revealed that students' past science experiences and gender had direct influence on their

commitment to choice of science and non-science majors. The students' past science experiences that directly influenced their commitment for choice of college majors were acquired by students being involved in one or some of the following experiences: extracurricular science activities, participation in various science organizations or clubs, science classroom activities, and number of other experiences. This causal relationship between these two variables, past science experiences and gender, indicate that students' commitment to choice of major for college may be related to the science experiences they acquired in the past.

Results from this study suggested that the predictor variables of parental background and self-actualization had an insignificant relationship with response variables. The finding concerning the predictor variable of parental background was partially consistent with the result from a prediction study by Talton and Simpson (1986) that reported family background did not show any significant relationship to adolescents' attitude toward science. However, it is in contrast to the findings of another causal modeling study by Schibeci and Riley (1986) who reported that parental education background had substantial influence on students' science achievement and their attitudes toward science. However, a deficiency of this study was that the researcher failed to report if parental background had any influence on

response variables. Perhaps if an aspect of parental background, other than education or occupation had been used, or if education and occupation had been considered individually, there may have been different findings.

Self-actualization traits were also unrelated to any of the response variables in the model. This finding is consistent with Wollam's (1986) findings that reported POI scales did not predict high school gifted students' academic achievement as measured by their cumulative four-year high school grade point average. However, it is in contrast to McKissick's (1976) findings that indicated Tc and I scores of POI significantly predicted academic achievement for a sample of female college students. One plausible explanation for self-actualization traits having no influence on any response variable could be that high school students, as a group, are often influenced more by external factors than by their own interpersonal values.

The data from the causal model were drawn, using path analytic techniques. Many paths in the model had significant relationships, indicating some support for causality between variables of the model as constructed. The results suggest that the magnitude of the causal relationships between these variables was small. Such results indicate that the data may be impacted by other uncontrolled or unspecified variables.

Implications

The results of this study provide information about late adolescents' science experiences, gender differences, and commitment to choice of science majors in relation to their choice of science careers. The data from this study indicated that the strongest correlation was between past science experiences and attitude toward science. The strength of relationship between two of these variables suggests the positive or negative attitude that students internalize about science can be influenced by the early science exposure they had in the past. If students had a solid foundation and understanding of science at an earlier stage of science learning, as they become older they would develop a better understanding of the sciences. Their better understanding of science may be reflected in a more positive attitude toward science at a later time. However, changing students' attitudes toward science in later adolescence may not be possible. It appears that early adolescence is a more appropriate target time for an intervention program in order to enrich students science background.

The results of this study also support the view that the kind of science experiences students had in the past does make a difference in their scientific plans. Findings suggest that their science experiences might be impacted by a chronological sequence of experience which begins at

elementary school and continues in middle school and junior high school. These experiences eventually appear to influence students' later choice of science and non-science majors. The implication of these results for science educators is that they cannot afford to overlook the effect of students' past science experiences on their choice of majors for college.

The science class experience did not affect students' attitude toward science positively as measured by the TOSRA. Scores actually went down slightly for males and substantially for female students. This could have happened because students lost interest on the instrument, or it may reflect the impact of experience in science classes after students, particularly female students, had been exposed to science experiments in the class and realized what actually was involved in a typical physical science class. This may have reduced students' interest in science and perhaps have influenced their choice of a scientific career.

The fact that females' view of scientists as normal people and males' attitude to scientific inquiry changed in a negative direction as a result of the class experience has interesting implications. The literature suggests that male adolescents have more interest in scientific inquiry than do their female peers. The data in this study contrast with reports in the literature that males' interest in scientific inquiry appeared to lessen over the time spent in the

classroom. This change may relate to the activity setting used by teachers. The setting may have considerable bearing on the way that male students could engage. A consequence, of their lack of engagement may be lost interest in scientific inquiry.

Females' perception of scientists as normal people changed in the course of science class experience. Perhaps the females' view changed because of the fact that they associated intense science activities in the classroom with the work of scientists. Gender differences, in favor of males, did result when students in class were compared in terms of their choice of science majors and also in the number of science and mathematics courses that they took in high school. This supported the reports in the literature that females' underrepresentation in college science majors is partially due to their having taken fewer science and mathematics courses in high school. However, the implication for teachers and guidance counselors or other professional staff in school is that they be cognizant of the importance of the relationship of science course work to students' decision about college plans. This implies that the professional staff in school should aid and encourage all students to enroll in science and mathematics courses as early adolescents. Furthermore, those who teach and guide interested, able female students during high school should

particularly encourage and assist them in making plans to pursue science careers.

The data indicate significant differences between students in AP classes and students in standard physics and chemistry classes. Scores were higher for AP students, in respect to variables of past science experience, number of science and mathematics courses they took in high school and their attitude toward science. The fact that AP students had higher mean scores in these variables is a valid indicator of their stronger science backgrounds. It gave them confidence to enroll in college preparatory courses. This also implies that AP students, because of their stronger science backgrounds and their taking AP courses, are equipped to be involved in majors leading to science careers. Despite more males than females being enrolled in AP classes in physics, there was, however, a large number of females in this study enrolled in AP college preparatory courses. The results showed that they have had fewer past science experiences and a poorer attitude toward science prior to taking these classes than did male student peers. Female students in AP classes who had a weaker science background may choose science majors and acquire more science experience at the college level. They perhaps may compensate for their weaker science backgrounds and poorer attitude toward science.

There were significant differences in mean scores of the POI scales for male and female students. Males statistically scored significantly on two of the POI scales, and females scored on six of the POI scales. This investigator's review of the literature indicates that this is the first science education study to report that late adolescent female students had statistically significant mean scores in more POI scales than did their male student peers. This implies that female students in this study appear to attain certain qualities which would lead to increased self-actualization--they are individuals described by Maslow (1968) as persons who are more sensitive to their own needs and feelings and less concerned with external evaluation. The implication is that, wherever possible, educators should find strategies which are appropriate to facilitate late adolescent females' self-actualizing process, plan an intervention in which females will be helped to fulfill their talents and raise their aspirations for challenging careers.

The research design and statistical analyses used in this study indicated the existence of causal relationships between some variables of interest. Perhaps the most important finding of this causal model, indicated by the data, was students' commitment to the choice of science and non-science majors. This variable was impacted not only by students' current attitude toward science but by their past

science experiences. This implies that some intervention should be started in early years to have a positive impact on student scientific plans.

Findings from the model constructed for this study provide new information for further model building. Eventually, a causal model will be constructed to accommodate new variables that can influence high school students' commitment for their choice of science and non-science majors.

Recommendations

This study proposed a conceptual path model to determine the influence of a number of predictor variables on student science achievement, attitude toward science, and commitment to the choice of science and non-science majors. The results indicated a statistically significant relationship between a number of variables in the model. The variables that had no influence on each other and their path was not statistically significant were eliminated from the model. Future work should employ a variety of causal modeling procedures using the late adolescent students who are enrolled in science classes. These procedures should include other variables that theoretically are important and that may influence student science achievement and attitude toward science. Perhaps, a new instrument should be employed to measure the past science experience variable.

The results indicated that the factors influencing male and female students' commitment to the choice of science and non-science majors are broad. Future research should use different measures of the model constructs and include additional variables such as the influence of the teacher and guidance counselors. In addition, they should use separate path models for male and female students with specific variables, such as family and personal life, which appear to inhibit the choice of science majors for females.

Future research should use other analytic strategies such as the analysis of covariance structure as offered in the LISREL method (Joreskog & Sorbom, 1978). The advantage of using LISREL is that it controls for possible covariates in the model and it has the capability of estimating a variety of causal models (Schibeci & Riley, 1986).

The sample drawn for this study was entirely volunteer. The future research should use a random sample from a different geographic population. A different causal pattern may well emerge from the sample.

Conclusions

There is a need to encourage adolescent students to take more science and mathematics courses and to participate in extracurricular science activities so that students can be adequately prepared to serve as scientists and engineers in the United States. This study provides additional

evidence of gender differences in past science experiences reported by late adolescents. Gender differences information on adolescents' commitment were also found in their choice of science and non-science majors. The data show that male and female students were significantly different in number of variables of interest. In past science experiences, females, although expressing interest in many science activities, did not participate. Their experiences did not parallel male students' experiences. This discrepancy between gender was more pronounced in the number of science and mathematics courses they took in high school. Overwhelmingly, male students appear to have stronger backgrounds in these courses than did female peers. The differences in the proportion of females and males taking science and mathematics courses in high school may also account for differences in their attitude toward science. The results from this study support the literature in Chapter 2 that suggests adolescent male students tended to have a more positive attitude toward science than did females. The differences between male and female students in pretest measure of attitude was slightly in favor of male students at the beginning of the academic year. Both gender attitudes declined as a result of class experience. This change of attitude declined significantly for female students at the middle of the year, at the time of posttest measure. The gender difference was also evident in all

classes of this study in respect to variables of interest. It was encouraging to find a significant number of female students enrolled in advanced physics and chemistry courses. However, female students had lower mean scores in variables of past science experiences, number of science and mathematics courses they took in high school, and attitude toward science than did male student counterparts in these classes. Despite these gender differences between students in AP classes, as a group, they had far stronger backgrounds in these variables than did students in standard physics and chemistry classes.

There were also gender differences in self-actualizing characteristics of high school students in this study. Maslow indicated that achieving full self-actualizing traits is a lifetime process, that these traits will not emerge before age 60. It appears that female students at adolescence in this study attain more self-actualizing traits than do male peers. Females were more sensitive to their own needs, more present oriented, and inner-directed. They held a constructive view of man and demonstrated a quality to accept one's natural aggressiveness more than their less self-actualizing male counterparts. Males appeared to be living in either the past or thinking about the future, and they tended to be influenced primarily by the needs and wishes of others.

The results of this also indicated a significant difference between high school students' commitment to their choice of science majors. A substantial number of males were committed to the physical sciences and engineering as their college majors, while female students appear to be more committed to biological science majors. Findings from this study support previous researchers' findings that fewer females than males choose careers in physical science and engineering (Ware & Lee, 1988; Jones & Wheatly, 1988).

The results of this study indicated that number of predictor variables in the causal model as constructed, significantly impacted the response variables of attitude toward science and commitment to the choice of science and non-science majors. The past science experiences represent an important predictor of study. The data show that male students, as a group, had adequate past science experiences that impacted their current positive attitude toward science. In addition, past science experiences directly impacted students' commitment to their choice of science and non-science majors for college. This finding suggests that students' past science experiences significantly influence their decision making process for their future scientific plans.

The research design and statistical analyses used in this study allow claims of causal relationships among some variables of interest. These findings were consistent with

previous research findings. The results from the study provide additional validity to previously identified characteristics of late adolescent students' science experience.

This research is significantly important for secondary school teachers and counselors since it suggests that their strategies to guide students can be more beneficial to students educational goals and plans. An active interest on the part of high school professional staff in students' future plans, particularly showing interest in female students' plans, is essential. Professional staff interest should be manifested in the form of encouragement of students to enroll in more college preparatory science and mathematics courses that are crucial to their plans to pursue college courses leading to science and engineering careers.

APPENDIX A
LETTER TO TEACHER

Dear Teacher:

I am a doctoral candidate in Foundations of Education at the University of Florida. I am requesting your students' participation in a study that relates to science education. I am trying to determine influences of 11th and 12th grade locus of control and level of self-actualization (refers to a process in which an individual is maximizing his/her potentials) on attitude toward science and science achievement.

A 1988 National Science Board Commission survey reports that 25 percent of all high school graduates are interested in majoring in natural science and engineering. Among these fields, life and health science are the most popular, followed by engineering. A tiny number of students plan to major in the physical sciences and mathematics. Consequently, in the United States there will soon be a serious lack of qualified technical personnel unless more students enter the scientific field of study.

A number of studies in physical science education has focused on cognitive processes to determine students' interest and achievement in science. However, this study will concentrate on psychological factors that may relate to science achievement in order to identify some characteristics of students who choose physical science courses.

This study involves two parts. 1) Your students will complete, in school, three questionnaires which measure locus of control, self-actualization, and attitude toward science at the middle of October 1989. The procedure will take each student approximately one hour and fifteen minutes to complete. 2) At the end of the Fall term, your students will complete the questionnaire which measures attitude toward science. This will take approximately twenty minutes. In addition, I will need to look at each student's Fall 1989 test scores in physics and chemistry courses.

All of the information gathered for this study will be kept strictly confidential; none of the questionnaires will require a personal identification. Information relating to your students will be handled through a numerical coding system.

I hope that you agree to participate in this study. I will contact you soon to answer your questions.

Your cooperation is greatly appreciated.

Sincerely,

Ahmad Narchi

APPENDIX B
PARENT CONSENT FORM

Dear Parent:

I am a doctoral candidate in Foundations of Education at the University of Florida. I am requesting your child's participation in a study that relates to science education. I am trying to determine influences of 11th and 12th grade locus of control (refers to a person's success or failure due to internal or external factors) and level of self-actualization (refers to process that individual is maximizing his/her potentials) on attitude toward science and science achievement.

This study involves two parts. 1) Your child will complete, in school, three questionnaires which measure locus of control, self-actualization, and attitude toward science at the beginning of Fall '89. The procedure will take him/her approximately one hour and twenty minutes to complete. 2) At the end of the Fall term, your child will complete the questionnaire which measures attitude toward science. This will take approximately twenty minutes. In addition, I will need to look at each student's Fall '89 test scores in physics and chemistry courses and his/her GPA.

I will ask your child to complete these questionnaires without interference with his/her academic time. All of the information gathered will be kept strictly confidential; none of the questionnaires will require a personal identification. All information relating to your child will be handled through a numerical coding system. Student's scores will only be published in group scores.

I anticipate no risk to your child for participating in this study, and participation or non-participation will also not affect your child's grades. No one participating will be given money. Parents are free to withdraw permission or a child may stop participating at any time they choose.

If you would like your child to participate or not participate in this project, please complete the section below and return to your child's teacher as soon as possible. Please feel free to contact me at 377-6479 should you have any questions. Thank you for your time and interest in this study.

I have read and understand the procedure described above. I agree to allow my child _____
(print name of child)
to participate in the procedure and I have received a copy of this description.

Signature of parent or guardian

Date

Signature of 2nd parent/witness

Date

I have read and understand the procedure described above. I do not agree to allow my child

(print name of child)
to participate in the procedure and I have received a copy of this description.

Signature of parent or guardian

Date

Signature of 2nd parent/witness

Date

With much appreciation for your cooperation,

Ahmad Narchi, Ph.D. Candidate

Date

APPENDIX C
STUDENT CONSENT FORM

Dear Student:

I would like to request your participation in a research study I am conducting. I am a doctoral candidate in Foundations of Education at the University of Florida. This study is intended to determine some psychological factors that may be related to attitude toward science and science achievement.

Your participation in this study involves two parts:
1) Completion of three questionnaires which take approximately one hour and twenty minutes at the beginning of the Fall '89 term. 2) Completion of one questionnaire that takes twenty minutes to complete at the end of the Fall term. In addition, I need to look at your test scores in physics and chemistry courses during the Fall term and your GPA.

Your responses will be kept confidential through a numerical coding system. Therefore, they will not be shared with anyone. You are not required to write your name on any questionnaires.

Your participation will be voluntary and no money will be given. In addition, participation or non-participation will not affect your grades. You may stop participating in this study at any time you choose. If you would like to have the result of your participation in this study, please indicate. ____ Yes or ____ No

I have read and I understand the procedure described above. I agree to participate in this study.

Student's Signature

Date

Ahmad Narchi, Ph.D. Candidate

Date

APPENDIX D
DEMOGRAPHIC SURVEY INFORMATION

Name _____ Student Code: _____

Female ____ Male ____ Your current grade in high school ____

Date of Birth: Month _____ Day _____ Year _____

Address: Street _____

City _____ State ____ Zip code _____

Phone number (area code) _____ County _____

1. Father's occupation _____

Mother's occupation _____

2. Father's level of education:

- _____ High school
- _____ College
- _____ Master's
- _____ Ph.D.
- _____ Medical professional
- _____ Law professional
- _____ Other

3. Mother's level of education:

- _____ High school
- _____ College
- _____ Master's
- _____ Ph.D.
- _____ Medical professional
- _____ Law professional
- _____ Other

4. Do you have any brother(s) or sister(s)?

_____ No
 _____ Yes If yes, what is your birth order in the
 family (1st, 2nd, etc.) _____

Please answer each of the following questions by circling the number that is most relevant to you.

Frequently	Often	Sometimes	Rarely	Never
5	4	3	2	

5. To what degree is your father encouraging you in science-related activities?

5	4	3	2	1
---	---	---	---	---

6. To what degree is your mother encouraging you in science-related activities?

5	4	3	2	1
---	---	---	---	---

7. To what degree is your brother(s) encouraging you in science-related activities?

5	4	3	2	1
---	---	---	---	---

8. To what degree is your sister(s) encouraging you in science-related activities?

5	4	3	2	1
---	---	---	---	---

9. To what degree is your other relative(s) encouraging you in science-related activities?

5	4	3	2	1
---	---	---	---	---

Please specify more relative(s) who have expressed an opinion.

_____ Grandmother
 _____ Grandfather
 _____ Uncle(s)
 _____ Other

10. To what degree are peer(s) a factor in making a choice in science-related activities?

5 4 3 2 1

11. Is there a teacher that you have had in elementary _____, middle school _____, or high school _____ who has encouraged you in science-related activities?

Please specify which teacher(s) _____

Please complete the following questions.

12. Please check the most typical science activities your parents pursue with you.

_____ Visiting science museums
_____ Attending science lectures
_____ Nature tours
_____ Science courses
_____ Science workshops, seminars
_____ General projects, e.g., making things that work, science fair, etc.
_____ Other (please specify) _____

13. In preschool and elementary school, what were your favorite play activities? (Check all that apply)

_____ Blocks, Legos or other building sets
_____ Board games
_____ Sports
_____ Puzzles
_____ Crafts
_____ Electronic games
_____ Action games
_____ Other (please specify) _____

14. In middle school, what were your favorite leisure/play activities? (Check all that apply)

_____ Playing games, e.g., cards, puzzles
_____ Sports
_____ Reading
_____ TV
_____ Computers
_____ Making science-related things
_____ Other (please specify) _____

15. What kind of science-related activities have you done?

- _____ Working in science lab on a project of your own
- _____ Making plants grow
- _____ Making a robot
- _____ Doing experiments
- _____ Building machines
- _____ Working with animals
- _____ Summer camps
- _____ Scouting
- _____ Other (please specify) _____

16. When did you first develop an interest in science-related activities?

- _____ In elementary school
- _____ Middle school
- _____ In junior high
- _____ During high school
- _____ Through summer activities
- _____ Other (please specify) _____

17. Which of the following factors were most important to your initial encouragement/interest in science?

(Choose up to 5 and rank the order 1 to 5 with 1 being most important)

- _____ Teacher's encouragement
- _____ Friend's encouragement
- _____ Fellow student's encouragement
- _____ Reading science information book
- _____ Influence of the media
- _____ Influence of mother
- _____ Influence of father
- _____ Influence of field trip
- _____ Interest in science career
- _____ Getting good grades in science courses
- _____ Summer job
- _____ Other (please specify) _____

18. Please list the science and math courses you have taken in high school and the courses you plan to take next year. Please indicate whether the courses were regular, advanced placement, and/or honors.

Science	Regular	AP	Honors	Grade Level

Math	Regular	AP	Honors	Grade Level

For Juniors only. Please indicate the courses you plan to take next year.

Science/Math	Regular	AP	Honors	Grade Level

19. Were there any particular high school science course(s) that interested you the most? _____ No _____ Yes

(Please check all that apply)

- _____ Physics
- _____ Chemistry
- _____ Biology
- _____ Math
- _____ Language
- _____ Social Studies
- _____ Humanities
- _____ General

20. What is your plan after high school graduation?

- _____ Go to college
- _____ Pursue business profession
- _____ Pursue governmental profession
- _____ Pursue independent technical or mechanical profession
- _____ Other (please specify) _____

21. If you plan to go to college, have you chosen a major?

- _____ Yes Please Specify _____
- _____ No
- _____ Possible

22. If your answer on question #21 is yes, please state which one of the following most influenced your selection of a college major?

(Choose up to 5 and rank the order 1 to 5 with 1 being most important)

- _____ Father's influence
- _____ Mother's influence
- _____ Other family member (Please specify) _____
- _____ Field trip
- _____ Summer project or school job
- _____ Teacher's influence
- _____ Friend or fellow student's influence
- _____ Reading science-related information
- _____ Successful performance in overall high school subjects
- _____ Doing well in advanced science courses in high school
- _____ Prospect of future vocational opportunities
- _____ Science fair project
- _____ Other (Please specify) _____

23. Which of the following factors are most important in determining career satisfaction for you?

(Choose up to 3 and rank the order 1 to 3 with 1 being most important)

- _____ Financial security
- _____ Opportunity to help others
- _____ Contributing available knowledge in the field
- _____ Meeting parental expectations
- _____ Meeting teacher expectations
- _____ Intellectual stimulations
- _____ Benefit to the world
- _____ High social status/prestige
- _____ Creative outlet
- _____ Other (Please specify) _____

REFERENCES

- Admission testing program of the college board, national college-bound seniors, annual series. (1976-1986). New York: College Entrance Examination Board.
- Admission testing program of the college board, profiles, college-bound seniors, annual series. (1981-1985). New York: College Entrance Examination Board.
- Advanced placement program, the college board, AP yearbook. (1986). New York: The College Entrance Examination.
- Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.
- Anderson, D. (1976). Parental childrearing practices and children's scores on the CNSIE. Unpublished manuscript. Alberta Social Services and Community Health Department.
- Asher, H.B. (1976). Causal modeling. Beverly Hills/London: Sage Publications.
- Baker, D.R. (1983). The relationship of attitude, cognitive ability, personality to science achievement in the junior high school. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Dallas, TX.
- Bank, B., Biddle, B., & Good, T. (1980). Sex roles in classroom instruction and reading achievement. Journal of Education Psychology, 72, 119-132.
- Barnett, R. (1974). Sex differences and age trends in occupational prestige. Journal of Counseling Psychology, 22, 35-38.
- Bar-Tal, C., & Bar-Zohar, Y. (1977). The relationship between perception of locus of control and achievement: Review and some educational implications. Contemporary Education Psychology, 2, 181-199.

- Baruch, R., & Nagy, J. (1977). Females and males in the potential scientist pool: A study of the early college career. Washington, DC: National Science Foundation.
- Becker, J.R. (1982). Differential treatment of females and males in mathematics classes. Journal for Research in Mathematics Education, 12(1), 40-53.
- Berrman, S.E. (1983). Who will do science? Minority and female attainment of science and mathematics degrees: Trends and causes. New York: Rockefeller Foundation.
- Bjorkquist, Ole. (1982). Preservice teacher education in elementary science. Unpublished doctoral dissertation, Northern Illinois University, DeKalb.
- Bloodworth, R.E. (1975). The effect of three different reward conditions on subsequent time spent on an intrinsically interesting task as a function of locus of control. Unpublished master's thesis, University of West Florida, Pensacola.
- Bonjean, C.M., & Vance, G. (1968). A short-form measure of self-actualization. Journal of Applied Behavior Science, 4, 299-312.
- Bonney, M.E. (1969). The normal personality. Berkeley: McCutchan.
- Brody, L.E., & Persson-Benbow, C. (1986). Social and emotional adjustment of adolescents extremely talented in verbal or mathematical reasoning. Journal of Youth and Adolescence, 15(1), 1-17.
- Brooks, M., & Hounshell, P.B. (1975). A study of locus of control and science achievement. Journal of Research in Science Teaching, 12(2), 175-181.
- Campbell, R.L., & Martinez-Perez, L.A. (1976). A study of relationships of science attitudes, achievement, and self-concept of pre-service teachers. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA (ERIC Document Reproduction Service No. ED 125 898).
- Campbell, P.B. (1986). What's a nice girl like you doing in a math class? Phi Delta Kappan, 67(7), 516-520.
- Campbell, P. & McCabe, G.P. (1982). Factors related to persistence in a computer science major (Tech. Rep. No. 82-15). West Lafayette, IN: Purdue University.

- Cervantes, R.A. (1976). Locus of control and achievement of Mexican American pupils. San Antonio, TX: D.C. Development Associates, Inc.
- College Board, AP Yearbook. (1986). Advanced placement program. New York: The College Entrance Examination Board.
- Crandall, V.J., Katkovsky, W., & Crandall, V.C. (1965). Children's belief in their own control of reinforcement in intellectual-academic situations. Child Development, 36, 91-109.
- Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16, 279-334.
- Damm, V. (1970). The relationship of ego strength to creativity and intelligence in high school students. Unpublished doctoral dissertation, Saint Louis University, Saint Louis.
- Dandes, H.M. (1966). Psychological health and teaching effectiveness. Journal of Teacher Education, 17, 301-306.
- Daniels, M. (1982). The development of the concept of self-actualization in the writing of Abraham Maslow. Current Psychological Review, 2, 61-76.
- Deboer, G.E. (1984). Factors related to the decision of men and women to continue taking science courses in college. Journal of Research in Science Teaching, 21, 325-329.
- Deboer, G.E. (1985). Characteristics of male and female students who experienced success or failure in their first college science course. Journal of Research in Science Teaching, 22(2), 153-162.
- Duntman, G.H. (1979). Race and sex differences in college science program participation. Washington, DC: National Science Foundation.
- Elliot, A.L. (1970). Fostering self-actualization of high school students through encounter group. Unpublished dissertation, United States International University, San Diego.
- Erickson, G.L., & Erickson, L.J. (1984). Females and science achievement: Evidence, explanations, and implications. Science Education, 68(2), 63-89.

- Ewen, R.B. (1980). An introduction to theories of personalities. New York: Academic Press.
- Farmer, R. (1984). Humanistic education and self-actualization theory. Education, 105(2), 162-172.
- Farmer, H. (1987). A multivariate model for explaining gender differences in career and achievement motivation. Educational Researcher, 16, 5-9.
- Fennema, E. (1983). Sex-related differences in education: Myths, realities, and intervention. Unpublished manuscript, University of Wisconsin, Madison.
- Fish, F.K. (1979). Self-concept of science ability held by eighth grade females: Science teachers as significant others. Paper Presented at the Meeting of the Midwest Sociological Society, Minneapolis, MN.
- Fisher, T.H. (1973). The development of an attitude survey for junior high school science. School Science and Mathematics, 73(8), 647-652.
- Fox, J., Knapp, R.R., & Michael, W.B. (1968). Assessment of self-actualization of psychiatric patients: Validity of the Personal Orientation Inventory. Educational and Psychology Measurement, 28, 565-569.
- Fox, L.H. (1981). The problem of women and mathematics. New York: Ford Foundation.
- Fox, L.J., & Denham, S.A. (1974). Value and career interest of mathematically and scientifically inclined youth. In J.C. Stanley, D.P. Keating, & L.H. Fox (Eds.), Mathematical talent: Discovery, description, and development (pp. 1-77). Baltimore: The John Hopkins University Press.
- Fraser, B.J. (1977). Attitude to the social implications of science: Its measurement and correlates. Australian Science Teachers Journal, 23(2), 96-99.
- Fraser, B.J. (1981) Test of science-related attitudes, handbook. Victoria, Australia: Australian Council for Educational Research.
- Fraser, B.J., & Butts, W.L. (in press). Relationship between levels of perceived classroom individualization and science-related attitudes. Journal of Research in Science Teaching.

- Fryrear, J.S., & Carlson, J. (1976). Locus of control scores of black and white adolescent subjects. An unpublished manuscript, Tulane University, New Orleans.
- Gardner, D., & Beatty, G. (1980). Locus of control change techniques: Important variables in work training. Education, 100, 237-242.
- Gasserly, P.L. (1978). An evaluation of the advanced placement program by students from 252 secondary schools at 20 colleges. In L.H. Fox, L. Brody, & D. Tobin (Eds.), Women and the mathematical mystique. Baltimore: Johns Hopkins University Press, 1980.
- Gibb, L. (1966). A study of the differences in sex, home background, educational background, work experience, extra-curricular participation, and self-actualization attainment in college juniors. Dissertation Abstracts, 27, 2258A.
- Gibb, L. (1968). Home background and student attainment. Journal of College Student Personnel, 9, 49-53.
- Goldman, J.A., & Olczak, P.V. (1975). The act of volunteering: Further evidence for the construct validity of the Personal Orientation Inventory. Journal of Clinical Psychology, 31(2), 287-292.
- Goldstein, K. (1939). The organism. New York: American Book.
- Goldstein, K. (1940). Human nature. Cambridge, MA: Harvard University Press.
- Gordon, D.A. (1977). Children's beliefs in internal-external control and self-esteem as related to academic achievement. Journal of Personality Assessment, 41, 383-386.
- Gordon, D.A., & Wilbur, A. (1974). The influence of maternal behavior on the self-concept of elementary school children during mother-child interactions. Unpublished honor's thesis, Emory University, Atlanta.
- Gowan, J.C. (1974). Development of the psychedelic individual. Northridge, CA: John Curtis Gown.
- Graham, M.F. (1978). Sex difference in science attrition. Dissertation Abstracts International, 39, 2570B.

- Haladyna, T., Olsen, R., & Shaughnessy, J. (1982). Relationships of student, teacher, and learning environment variables to attitude toward science. Science Education, 66(5), 671-687.
- Handley, H.M., & Morse, L.W. (1983). Two-year study relating adolescents' self-concept and gender role perception to achievement and attitude toward science. Paper presented at the Annual Meeting of the National Association of Research in Science Teaching, Dallas, TX.
- Hansen, R., & Neujahr, J. (1974). Career development of males and females gifted in science. Journal of Educational Research, 68, 43-45.
- Haury, D.L. (1984). Science locus of control orientations and the attitude expressed by elementary teacher interns toward science teaching. Dissertation Abstracts International, 44, 2429A.
- Haury, D.L. (1989). The contribution of science locus of control orientation to expressions of attitude toward science teaching. Journal of Research in Science Teaching, 26(6), 503-517.
- Heintschel, R.M. (1978). An analysis of the relationship between science teacher self-actualization and science student attitude and achievement. Dissertation Abstracts International, 39, 3501A.
- Hoffman, E. (1988). The right to be human. Los Angeles: Jeremy P. Tarcher, Inc.
- Hollinger, C. (1983). Self-perception and the career aspirations of mathematically talented female adolescents. Journal of Vocational Behavior, 22(1), 49-62.
- Hoyenga, K.B., & Hoyenga, K.T. (1979). The question of sex differences. Boston: Little, Brown and Co.
- Hurd, P.D. (1978). Final report of the National Science Foundation early adolescence panel meeting. Washington, DC: National Science Foundation.
- Ilardi, R.L., & May, W.T. (1968). A reliability study of Shostrom's Personal Orientation Inventory. Journal of Humanistic Psychology, 8, 68-72.

- International Association for the Evaluation of Educational Achievement. (1986). Comparison of the achievement of American elementary and secondary students with those abroad (Publication No. 683 EPW). Washington, DC: U.S. Government Printing Office. (NTIS No. P88-177 969/AS).
- Ivie, S.D. (1982). Self-actualization: Its use and misuse in teacher education. Journal of Teacher Education, 33(5), 24-17.
- Janda, L.H., O'Grady, K.E., & Capps, C.F. (1978). Fear of success in males and females in sex-linked occupations. Sex Roles, 4, 43-50.
- Johnson, E.G., Jr. (1967). A comparison of academically successful and unsuccessful college of education freshmen on the measures of "self." Unpublished doctoral dissertation, University of Toledo, Toledo.
- Johnson, T.F., & Butts, D.P. (1983). The relationship among college science student achievement, engaged time, and personal characteristics. Journal of Research in Science Teaching, 20(4), 357-366.
- Jones, K.M. (1975). The construction and validation of an instrument to measure self-actualization as defined by Abraham Maslow. Dissertation Abstracts International, 36, 2026A.
- Jones, G.M., & Wheatly, J. (1988). Factors influencing the entry of women into science and related fields. Science Education, 72(2), 127-142.
- Joreskog, K.G., & Sorbom, D. (1978). LISREL.IV: Analysis of linear structural relations by the method of maximum likelihood. Chicago: National Educational Resources.
- Kahle, J.B. (1982). Sex-related differences in pre-college science findings of the science meta-analysis project. Paper presented at the Annual Meeting of the American Educational Research Association, New York. (ERIC Document Reproduction Service No. Ed 216-909).
- Kahle, J.B. (Ed.). (1985). Women in science: A report from the field. Philadelphia: The Farmer Press.
- Kahle, J.B., & Lakes, M.K. (1983). The myth of equality in science. Journal of Research in Science Teaching, 20, 131-140.

- Kahle-Butler, J.B., Matyas-Lakes, M.K., & Cho-Hyung, L. (1985). An assessment of the impact of science experiences on the career choice of male and female biology students. Journal of Research in Science, 22(5), 385-394.
- Kandel, D.B., & Lesser, G.S. (1969). Parental and peer influences on educational plans of adolescents. American Sociological Review, 34, 213-223.
- Keeves, J.Q., & Read, A.D. (1974). Sex differences in preparation for scientific occupations (IEA Report No. V 1974, 6). Hawthorn, Australia: Australian Council for Education.
- Kelly, A. (1981). The missing half: Girls and science education. Manchester, England: Manchester University Press.
- Kelly, A. (1985). The construction of masculine science. British Journal of Sociology Education, 6(2), 133-153.
- Kelly, A., Whyte, J., & Smail, B. (1984). Girls into science and technology: Final report. London: University of Manchester.
- Kerr, B.A. (1985). Smart girls, gifted women. Columbus, Ohio: Ohio Psychology Publishing Company.
- Klavetter, R.E., & Mogar, R.E. (1967). Stability and internal consistency as a measure of self-actualization. Psychological Reports, 21, 422-424.
- Klopfer, P.D.H. (1971). Evaluation of learning in science. In B.S. Bloom, J.T. Hastings, and G.F. Madaus (Eds.), Handbook of summative and formative evaluation of student learning (pp. 50-68). New York: McGraw-Hill.
- Knapp, R.R. (1965). Relationship of a measure of self-actualization to neuroticism and extraversion. Journal of Counseling Psychology, 29(2), 168-172.
- Knapp, R.R. (1976). Handbook for the Personal Orientation Inventory. San Diego: Educational and Industrial Testing Service.
- Knapp, R.R., & Comrey, A.L. (1973). Further construct validation of a measure of self-actualization. Education and Psychological Measurement, 33, 419-425.

- Knapp, R.R., & Fitzgerald, O.R. (1973). Comparative validity of the logically developed versus "purified" research scales for the Personal Orientation Inventory. Educational and Psychological Measurement, 33, 971-976.
- Knapp, R.R., & Shostrom, E.L. (1976). POI outcomes in studies of growth group: A selected review. Group and Organization Studies, 1, 187-202.
- Koballa, T.R., Jr. (1988). The determinants of female junior high school students' intentions to enroll in elective physical science courses in high school: Testing the applicability of the theory of reasoned action. Journal of Research in Science Teaching, 25(6), 479-492.
- Kremer, B.K., & Walberg, H.J. (1981). A synthesis of social and psychological influences on science learning. Science Education, 65(1), 11-23.
- Krynowsky, B.A. (1988). Problem in assessing student attitude in science education: A partial solution. Science Education Assessment Instruments, 72(4), 575-584.
- Lee, V. (1987). Identifying potential scientists and engineers: An analysis of the high school-college transition. Washington, DC: Office of Technology Assessment. (NTIS No. P88-177 944.AS).
- Lee, P.W.H., & Leih-Mak, F. (1984). Locus of control, teachers' ratings and task performance of physically handicapped children. The Exceptional Child, 3(2), 128-133.
- Lefcourt, H.M. (1983). Research with the locus of control construct, volume 2. New York/London: Academic Press.
- Leib, J.W., & Snyder, W.V. (1967). Effects of group discussion on underachievement and self-actualization. Journal of Counseling Psychology, 14, 282-285.
- Leib, J.W., & Snyder, W.V. (1968). Achievement and positive mental health. Journal of Counseling Psychology, 15, 388-389.
- Lowry, R.J. (1973). A.H. Maslow: An intellectual portrait. Monterey, CA: Brook/Cole Publishing Company.

- Lucas, K.B., & Tulip, D.F. (1980). Scientific literacy of high school students. Paper presented at Annual Conference of Australian Science Teachers Association, Canberra, Australia.
- Marcus, D. (1975). The effect of a behavior modification program on locus of control and interpersonal distance/scores of children. Unpublished honor's thesis, Emory University, Atlanta.
- Maslow, A.H. (1937). Dominance of feeling, behavior, and status. Psychological Review, 44: 404-420.
- Maslow, A.H. (1943). A theory of human motivation. Psychological Review, 50, 370-396.
- Maslow, A.H. (1950). Self-actualization people: A study of psychological health. Personality Symposium, 1, 11-34.
- Maslow, A.H. (1954). Motivation and personality. New York: Harper and Bros.
- Maslow, A.H. (1968). Toward a psychology of being. New York: D. Van Nostrand.
- Maslow, A.H. (1970). Motivation and personality, 2nd edition. New York: Harper and Row.
- Maslow, A.H. (1971a). Science and self-actualization, in the manas reader. New York: Crossman Publisher.
- Maslow, A.H. (1971b). The further reaches of human nature. New York: Viking Press.
- Matyas, M. (1986). Persistence in science-oriented majors: Factors related to attrition among male and female students. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.
- McGee, M.G. (1979). Human spatial abilities: Psychometric studies and environmental, genetic, hormonal, and neurological influences. Psychological Bulletin, 86, 889-918.
- McKissick, G.C. (1976). The relationship among the factors of academic ability, self-actualization, and achievement of seniors in a four-year liberal arts college for women. (Doctoral dissertation, University of Missouri, 1975). Dissertation Abstracts International, 39, 3501A.

- McLure, G.T., & Piel, E. (1978). College bound girls and science careers: Perceptions of barriers and facilitating factors. Journal of Vocational Behavior, 12, 172-183.
- Mead, M., & Metraux, R. (1957). Image of the scientist among high school students. Science, 126, 384-390.
- Medin, J.A. (1985). Test anxiety, locus of control and mathematics achievement placement as correlates to achievement in mathematics by students in junior high school. Unpublished doctoral dissertation, The American University, Washington, DC.
- Moore, R.W., & Sutman, F.Y. (1970). The development, field test and validation of an inventory of scientific attitudes. Journal of Research in Science Teaching, 7, 85-94.
- Morgan, R., & Culver, V. (1978). Locus of control and reading achievement: Applications for the classroom. Journal of Reading, 21, 403-408.
- Morris, R.D. (1976). Interpersonal and its mediation variables in Ghana, West Africa. Unpublished honor's thesis, Emory University, Atlanta.
- Munby, H. (1983). Thirty studies involving the "Scientific Attitude Inventory," what confidence can we have in this instrument. Journal of Research in Science Teaching, 20(2), 141-162.
- Murphy, S.M. (1975). A comparison of suburban public, rural public, and suburban Catholic high school students on the Personal Orientation Inventory. Dissertation Abstracts International, 36, 203A.
- Murray, M.E. (1966). An exploration of the relationship of self-actualization to teacher success. Unpublished master's thesis, Pennsylvania State University, University Park.
- National Science Foundation. (1988). Women and minorities in science and engineering (Contract No. SRS-8515461). Washington, DC: National Academy Press.
- Neujahr, J., & Hansen, R. (1970). The prediction of careers in science from high school data. Journal of Research in Science Teaching, 7(4), 391-394.

- Novick, S., & Duvdvani, D. (1976) The scientific attitudes of tenth grade students in Israel as measured by the Scientific Attitude Inventory. School Science and Mathematics, 76, 9-14.
- Nowicki, S. (1976). The factor structure events during developmental periods and their relation to locus of control orientation. Journal of Consulting and Clinical Psychology, 46, 1552-1553.
- Nowicki, S., & Roundtree, J. (1971). Correlates of locus of control in secondary school population. Developmental Psychology, 4(3), 477-478.
- Nowicki, S., & Strickland, B.R. (1973). A locus of control scale for children. Journal of Consulting and Clinical Psychology, 40, 148-154.
- Nyberg, V.R., & Clarke, S.T. (1982). School subjects attitude scales. Alberta Journal of Educational Research, 28(2), 175-187.
- Oakland, J.A., Freed, F., Lovekin, A., Davis, J.P., & Camilleri, R. (1978). A critique of Shostrom's Personal Orientation Inventory. Journal of Humanistic Psychology, 18(2), 75-85.
- Office of Technology Assessment. (1987). Educating scientists and engineers grade school to grad school (OTA Publication No. SET-377). Washington, DC: U.S. Government Printing Office.
- Office of Technology Assessment. (1989). Elementary and secondary education for science and engineering--A technical memorandum. (OTA,TM-SET-41). Washington, DC: U.S. Government Printing Office.
- Oliver, S.J., & Simpson, R.D. (1988). Influence of attitude toward science, achievement motivation, and science concept on achievement in science: A longitudinal study. Science Education, 72(2), 143-155.
- Otten, M.W. (1977) Sex differences on the Personal Orientation Inventory. Journal of Personality Assessment, 41(1), 63-65.
- Patterson, E.W. (1988). The effects of participation in required and not required community service program on the process of self-actualization in high school students. (Doctoral dissertation, University of Florida, 1987). Dissertation Abstracts International, 48, 2016A.

- Pervin, A.L. (1980). Personality: Theory and research. New York: John Wiley & Sons, Inc.
- Peterson, K., Kauchak, D., & Yaakobi, D. (1980). Science students' role-specific self-concept: Course, success, and gender. Science Education, 64(2), 169-174.
- Roberts, A. (1971). The self-esteem of disadvantaged third and seventh graders. Unpublished doctoral dissertation, Emory University, Atlanta.
- Rogers, C.R. (1951) Client-centered therapy. Cambridge, MA: The Riverside Press.
- Rogers, C.R. (1959). A theory of therapy, personality and interpersonal relationships as developed in the client-centered framework. In Koch (Ed.), Psychology: Study of science (pp. 184-256). New York: McGraw-Hill.
- Rogers, C.R. (1962). The interpersonal relationship: The core of guidance. Harvard Educational Review, 32, 416-426.
- Rotter, J.B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs, 80(1, Whole No. 609), 1-28.
- Sadker, D., & Sadker, M. (1985). Sexism in the schoolroom of the '80's. Psychology Today, 19, 54-57.
- Schafer, J.E. (1981). Effect of individualized goal-setting on college biology students' locus of control. Journal of Research in Science Teaching, 18(5), 397-402.
- Schibeci, R.A., & McGaw, B. (1980). Analysis of data from attitude instruments. In Australian association for research in education, youth, schooling and employment. Paper presented at the 1980 Annual Conference, Sydney.
- Schibeci, R.A., & Riley, N.J.P. (1986). Influence of students' background and perceptions on science attitudes and achievement. Journal of Research in Science Teaching, 23(3), 177-187.
- Seipp, K.M. (1983). Psychological maturity: A necessary prerequisite for self-actualization. Dissertation Abstracts International, 44, 327B.
- Sherman, J. (1978). Sex related cognitive differences: An essay on theory and evidence. Springfield, IL: Charles C. Thomas.

- Shostrom, E.L. (1964). An inventory for the measurement of self-actualization. Educational and Psychological Measurements, 24, 207-218.
- Shostrom, E.L. (1966). Manual for the Personal Orientation. San Diego: Educational and Industrial Testing Service.
- Shostrom, E.L. (1974). Manual for the Personal Orientation Inventory. San Diego: EDITS, Educational and Industrial Testing Service.
- Short, N. (1976). Persistence in children as a function of development level, locus of control, and skill and chance instructions. Unpublished honor's thesis, Emory University, Atlanta.
- Simpson, R.D., & Oliver, S.J. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. Science Education, 69(4), 511-526.
- Simpson, R.D., & Troast, K.M. (1982). Influences on commitment to and learning of science among adolescent students. Science Education, 66, 763-781.
- Smith, J.A. (1973). The prediction of academic success from self-actualizing values. Unpublished doctoral dissertation, University of Maryland, College Park.
- Smith, O.C., & Gessler, J. (1989). Advising and educating the engineers of tomorrow. The Science Teacher, 56(5), 33-36.
- Steinkamp, M.W., & Maehr, M.L. (1983). Affect, ability, and science achievement: A quantitative synthesis of correlational research. Review of Educational Research, 53, 369-396.
- Steinkamp, M.W., & Maehr, M.L. (1984). Gender difference in motivational orientation toward achievement in school science: A quantitative synthesis. American Educational Research Journal, 21, 39-59.
- Survey of Westinghouse science talent search winners. (1985). Washington, DC: Westinghouse Electric Corporation.
- Talton, L.E., & Simpson, R.D. (1986). Relationships of attitudes toward self, family, and school with attitude toward science among adolescents. Science Education, 70(4), 365-374.

- Talton, L.E., & Simpson, R.D. (1985). Relationships between peer and individual attitudes toward science among adolescent students. Science Education, 69(1), 19-24.
- Thomas, G. (1973). A baseline evaluation of child caring institutions in Georgia Regional Institute for Social Welfare Research School of Social Work. Unpublished doctoral dissertation, University of Georgia, Athens.
- Thomas, G. (1984). Determinants and motivations underlying the college major choice of race and sex groups. Unpublished manuscript. National Academy of Science, Office of Scientific and Engineering Personnel, Washington, DC.
- Tosi, D.J., & Lindamood, C.A. (1975). The measurement of self-actualization: A critical review of the Personal Orientation Inventory. Journal of Personality Assessment, 39(3), 215-224.
- A trend study of high school offerings and enrollments: 1972-73 and 1981-82. (1984). (NCEs 84-224). Washington, DC: National Center for Education Statistics.
- Tyler, J.D., & Holsinger, D.N. (1975). Locus of control differences between rural American Indian and white children. Journal of Social Psychology, 95, 149-155.
- U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, 34(1). (January, 1987)
- Vockell, E.L., & Lobonc, S. (1981). Sex-role stereotyping by high school females. Journal of Research in Science Teaching, 18(3), 209-219.
- Walberg, H.J. (1967). Dimensions of scientific interests in boys and girls studying physics. Science Education, 51(2), 111-116.
- Walberg, H.J. (1983). Synthesis of research on teaching. In M.C. Wittrock (Ed.), Handbook of research on teaching. Washington, DC: American Educational Research Association.
- Wantman, L.K. (1986). Promoting excellence: A study of the families of origin of Nobel Prize winners (family therapy, self-actualization, achievement). Dissertation Abstracts International, 47, 1776B.

- Ward, B. (1979). Attitude toward science: A summary of results from the 1976-77 national assessment of science (Report No. NAEP 08-5-02). Denver, CO: Educational Commission of the States, National Assessment Educational Progress. (ERIC Document Reproduction Service No. Ed 177-017).
- Ware, N., & Dill, D. (1986). Persistence in science among mathematically able male and female college students with pre-college plans for a scientific major. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.
- Ware, N.C., & Lee, V.E. (1988). Sex differences in choice of college science majors. American Educational Research Journal, 25(4), 593-614.
- Ware, N.C., Steckler, N.A., & Leserman, J. (1985). Undergraduate women: Who choose a science major? Journal of Higher Education, 56, 73-84.
- Waters, D.B. (1971). Differential effects of skill and chance instructions on persistence, time and attention breaks as a function of locus of control in elementary school children. Unpublished doctoral dissertation, Emory University, Atlanta,
- Weiner, H.R. (1975). Resistance to extinction as a function of locus of control. Unpublished master's thesis, University of Hawaii, Honolulu.
- Welch, W.W. (1983). Assessment of education. Progression News, 16(2), 1.
- Welch, W.W. (1985). Sugar and spice and all things nice? Australian Educational Research, 12(2), 5-23.
- Will, B.S. (1974). Personality variables which discriminate between groups differing in level of self-actualization. Journal of Counseling Psychology, 2(3), 222-227.
- Wise, G.W., & Davis, J.E. (1975). The Personal Orientation Inventory: Internal consistency, and sex differences. Psychological Reports, 36, 847-855.
- Wollam, J. (1986). The Relationship of measures of self-actualization to gifted students' academic achievement. Dissertation Abstracts International, 47, 844A.

- Wooddell, G.D., Fletcher, G.H., & Dixon, T.E. (1982). Future study for the adolescent gifted: A curriculum evaluation. Journal for the Education of the Gifted, 5(1), 24-33.
- Wright, J.D., & Hounshell, P.B. (1981). A survey of interest in science for participants in a junior science and humanities symposium. School Science and Mathematics, 81, 378-382.
- Zerega, M.E., Haertel, G.D., Shiow-Ling, T., & Walberg, H.J. (1986). Late adolescent sex differences in science learning. Science Education, 70(4), 447-460.
- Zoller, U., & Watson, F.G. (1974). Teacher training for the second generation of science curricula: The curriculum-proof teacher. Science Education, 58, 93-103.


BIOGRAPHICAL SKETCH

Ahmad Narchi was born in Tehran, Iran, on June 7, 1952. He moved to the United States in 1974. He subsequently attended Eastern Illinois University in Charleston, Illinois, where he earned his Bachelor of Science degree in nutrition science in 1980 and his Master of Science degree in guidance and counselor education in 1981. He was admitted into the Ph.D. Program of the Foundations of Education Department in 1982, in the educational psychology Program.

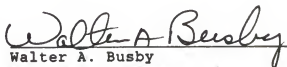
Mr. Narchi, while carrying out his graduate studies, taught introduction human growth and development courses in 1983-1985, at the University of Florida and Santa Fe Community College, Gainesville, Florida. Mr Narchi served as vice president, in 1985, and president, in 1986, of the Students for the Advancement of Gerontological Education (SAGE) organization. He also administered a class on the psychology of aging through the Older Americans Council in Gainesville, Florida.

Mr. Narchi has interest in educational psychology and human growth and development and science education. He plans on working in these areas.

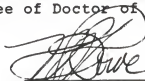
I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


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Associate Professor of
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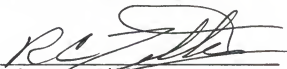
I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


Walter A. Busby
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Mary Budd Rowe
Professor of Instruction
and Curriculum

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


Robert C. Ziffer
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This dissertation was submitted to the Graduate Faculty of the College of Education and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December 1990



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